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THE BEGINNING OF EXCAVATION on the direct line of the New York Underground Rapid Transit Railway was celebrated on May 14, when Corporation Counsel Whalen removed the first shovelful of earth at Broadway and 150th St., and speeches were delivered by Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., Chief Engineer Rapid Transit Commission Contractor Mr. John B. McDonald, and others prominently connected with the work. The place at which work was begun is on sub-contract section No. 13, for which Mr. L. B. McCabe has the contract. The work was continued by a force of men on May 15. Applicants for the positions of Assistant Engineers on the staff of the Rapid Transit Commission have been numerous. At the civil service examination for these positions, held on May 14, 101 applicants competed, and it was announced that 100 other applicants, who could not then be accommodated, would be examined at a later date. There will be three grades of Assistant Engineers employed, carrying salaries of $1,200, $1,500 and $1,800, respectively.

THE CONTROL OF THE LONG ISLAND RAILWAY system by the Pennsylvania R. R. Co., opens up large possibilities for increased traffic facilities, says "Bradstreets." Among the changes discussed is the establishment of a large freight terminal at Greenville, N. J., from which cars would be transferred by floats to Bay Ridge, where the Long Island lines would distribute this freight to Brooklyn and Long Island. A tunnel route is also planned to connect these points. With the Hell Gate bridge built, a direct connection would also be secured with the New York Central and the Hartford and New Haven railway systems. The Long Island Railway controls important terminal facilities, and it is practically a belt-line reaching all parts of Brooklyn, with its million or more inhabitants. Better facilities for moving freight would encourage the development of many industries, and this seems to be one of the purposes of the Pennsylvania Co.

THE PROPOSED BRIDGE ACROSS SYDNEY HARbor, New South Wales, is reported upon by Mr. Geo. W. Bell, U. S. Consul at Sydney, as follows:

> There has been for several years considerable agitation regarding the construction of this bridge. Sydney is a city of great wealth; and within the metropolitan area, it is now claimed, there are about 425,000 people, fully 40,000 of whom reside in the North Sydney suburb. Although a more convenient method of crossing the harbor is desired, and the northern suburb is growing very rapidly, the travel by vehicle is comparatively lighter in this than in an American city of the same size, and a rational doubt may be entertained as to an immediate construction of the work. In this country all such works are carried on by the government, and as there are political parties—"ins and outs" to promise and oppose—rather long agitation may be looked for before any administration will assume the responsibility of taxing the people inhabiting this 310,000 square miles of territory for the benefit of so small a proportion of the population. However, the people are enterprising, and, unless there should be a serious and protracted check to the prosperity of the colony or the growth of the city, an earnest effort to accomplish this work may be looked for in no distant future.

THE DELAWARE VALLEY & KINGSTON R. R., recently approved by the New York Railroad Commission, will be delayed by an appeal from the decision of the Commission to the New York Supreme Court. The appeal has been filed by the New York, Ontario & Western R. R. Co., which opposed the proposed line before the Commission. As explained in our issue of May 3, the consent and approval of the State Railroad Commission is a necessary preliminary to the construction of any railroad in the State of New York. The decision of the Railroad Commission either in favor or against the project is subject to review by the higher courts of the State. In case the Delaware Valley & Kingston projectors should receive the approval of the Supreme Court, it is said the case will be carried to the Court of Appeals.

A TRAIN, VESTIBULED FROM END TO END, and with its sides extended to within a few inches of the track, to minimize the resistance from air pressure, was tested on May 8 on the tracks of the Baltimore & Ohio R. R. The train is the invention of Mr. F. U. Adams, who is said to be backed by plenty of capital. Besides its special vestibule and side construction, the train has its rear end pointed and the locomotive and tender made flush with the sides of the cars behind. Ventilation is secured by air ducts running between the covering and the upper and lower decks. The results of the test of the train were reported by Mr. Adams to the newspapers as follows: "The train was in charge of Engineer Mike Kirby, and engine 822, a small 50-ton locomotive, was sent out to pull the six cars. The best runs were 3½ miles in 2½ minutes; 10 miles in 8 minutes, and 18 miles in 16 minutes. From Frederick Junction up the hill to Mount Airy the speed of 35 miles was maintained. On all down grades it was necessary to apply the air brakes. It was demonstrated that the train, with this small engine, can easily make 60 miles an hour on levels."

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear end collision between two sections of a fast freight train in the Baltimore & Ohio R. R. tunnel at Philadelphia, Pa., on May 12. The accident was caused by the signalman falling asleep at his post, and it resulted in the death of the engine driver and fireman of the second section and of five tramps, who are thought to have been stealing rides. The tunnel in which the collision occurred runs under 25th St., from Callowhill St. to Fairmount Park, about 2,800 ft., and has an up-grade from the Callowhill St. entrance, or out of the city. The first section of the fast freight was stalled on this grade, and it was finally divided, the locomotive proceeding with 26 cars over the grade, while 17 cars were left standing in the tunnel. It was the duty of the signalman to protect the cars in the tunnel by the usual danger signal, but, being asleep, as he admits, he failed to do so, and the second section of the freight, running at high speed, to overcome the tunnel grade, crashed into the standing cars. The wreckage filled the tunnel, and, catching fire from the locomotive, burned fiercely for several hours, despite the exertions of the city fire department to extinguish the flames.

AMERICAN LOCOMOTIVES to the value of $4,000,000 have been exported in the nine months ending March 31, as compared with $1,000,000 in the corresponding period of 1894, and $2,800,000 in 1896.

CHINESE FOREIGN TRADE, says the U. S. Bureau of Statistics, developed rapidly in 1899, especially with the United States. The "Returns of Trade," issued by the Imperial Maritime Customs Service of China, reports that the total trade of 1899 exceeded all previous records, and amounted to a total of 460,533,288 Haikwan taels, or $331,583,967, with the value of the Haikwan tael averaging $0.72 in 1899. This aggregate is more than double the figures of 1890 and 91,916,805 Haikwan taels in excess of that for 1898. The trade with the interior states was unusually brisk along the lines of the newly opened railways. The net value of the import trade was 264,748,456 Haikwan taels, a net advance of 55,169,122 taels over the previous year. In these imports American sheeting rose from 2,483,991 to 3,975,903 pieces.

JOBOS, PORTO RICO, some miles east of Ponce, may be converted into a new port by American capital. The surveys of the Coast and Geodetic Survey show it to be one of the best harbors on the coast, as it is thoroughly land-locked and has few bars or other obstructions. A part of the scheme is to drive a 3-mile tunnel through a mountain to divert the Rio Plata to the site of the proposed new town. It is said that about $2,000,000 was expended upon this tunnel during the Spanish regime.

CHANGES IN THE HARBOR LINE of New York are being considered by the Harbor Line Board. The Riparian Commission of New Jersey asks permission to extend the harbor lines on the Hudson River from Pleasant Valley to Bloomers. The most important change in its possibilities, however, is the request of the Pennsylvania R. R. Co. to modify the existing lines on the Jersey flats opposite Greenville, N. J. This is apparently in line with the reported establishment of a terminal freight yard at that point to connect by car-floats with the newly acquired terminal at Bay Ridge. The Chamber of Commerce raised some objection to the proposed filling-in as likely to interfere with present channels by changing the natural dredging effect of the tides. The railway company wants the line moved out 2,000 ft., and the plans call for a pier 2,000 ft. wide on the bulkhead line, with a total length of 8,000 ft. When completed this pier would not reach within 3,200 ft. of the deep water channel. Col. H. M. Robert, Engineer Corps, U. S. A., remarked that there was no need to worry about the channel.

A NOTABLE MODEL OF A HYDRAULIC DREDGE, built by the firm of L. Smit & Son, of Kinkerdijk, Holland, will be exhibited at the Paris Exposition. In addition to its being a finished specimen of the modeller's art, this model is designed and constructed to illustrate the actual working of the pumps and all other dredging apparatus with which the full size dredge is equipped, arranged as in the original vessel. The miniature dredge is on a scale of ½-in. per ft.—equivalent to one twenty-fourth of the size of the original—and has been constructed of aluminum, piece by piece, as in the real vessel it represents. It will be shown afloat, and at work in a large tank of water, dredging material from the bottom of the tank, and depositing through the hopper doors, or pumping it overboard into hopper barges alongside, or delivering it through lines of piping ashore. The pumps with which the model is equipped are actuated by an electric motor carried on board, with the necessary cells, and the material dealt with will be ground rice or some equivalent substance to represent the sand and gravel dealt with in actual working. This model was built by the model-making works of Kelso & Co., of Glasgow, Scotland.

THE NAVAL APPROPRIATION BILL, as passed by the Senate on May 14, authorizes the Secretary of the Navy to procure armor of the best quality at $445 per ton; but if he be unable to obtain it at that price he is then authorized to pay $545 per ton for the armor for the battleships "Maine," "Ohio" and "Missouri," and proceed to erect an armor factory, to cost not to exceed $4,000,000, one-half of which amount is made immediately available. The sentiment in favor of the erection of a government armor plant was very strong, and the proposition to erect such a plant at once was defeated by a vote of 24 to 22. About 30,000 tons of armor is now needed for vessels completed and provided for, an amount about as great as the entire amount of armor thus far purchased since the construction of modern armored vessels by the United States began. The gross receipts of the steel companies for this amount of armor at the above price of $445 per ton would be $13,350,000. It is altogether likely that they will accept this figure; for to take the contrary course would certainly result in the construction of a government plant and the loss of all future business from the government. Five Holland submarine torpedo boats are also provided for in the bill as passed by the Senate, at a maximum price of $170,000 each.

THE "GROSSER KURFURST," the latest addition to the freight transatlantic steamships of the North German Lloyd Line, reached New York on her maiden trip May 15. She has a length over all of 581 ft. 6 ins., 62 ft. beam and 39 ft. depth. Her total displacement is 22,000 tons, and the registered tonnage is 12,000. The motive power is two quadruple-expansion engines of 8,000 I. HP. each, giving an average speed of 15 knots. The cylinder diameters are 27⅝, 41, 59 and 83½ ins., and the stroke is 53⅛ ins. The Scotch boilers which supply steam have 700 sq. ft. of grate surface and 26,000 sq. ft. of heating surface, and are fired with natural draft. Accommodation is provided for 250 first cabin and 150 second cabin passengers.

STATISTICS OF GAS ENGINES using blast furnace gas are given for a number of European countries by Mr. Emile Demenge as follows: Germany, 41 engines, aggregating 21,950 HP.; Luxemburg, 12 engines, aggregating 6,760 HP.; Belgium, 8 engines, aggregating 3,700 HP.; France, 8 engines, aggregating 3,250 HP., and England, 6 engines, aggregating 2,000 HP.

THE BIG BLAST AND POWER DEVELOPMENT OF THE PIKE'S PEAK POWER CO.

By W. M.

On Dec. 18, 1899, at West Beaver Creek, Teller Co., Colo., occurred the second largest blast in the history of high explosives. During the summer of 1899, the Pike's Peak Power Co., of Victor and Cripple Creek, Colo., bought large tracts of ranch and placer lands at and above the junction of Beaver Creeks, including a site for a large steel-faced granite-filled dam.

This dam site, with its six miles of pipe line running to "Station A," is easily accessible from the great gold camp in the Cripple Creek district. For the construction of this large dam 42,000 cu. yds. of rock was required, and close at hand "Vesuvius Butte" reared its apex some 300 ft. above the base line of the dam. The company decided to displace sufficient granite from the butte to build the dam, the top of which will have an assumed elevation of 9,075 ft. above the sea.

About 75 ft. below the apex there could be seen from the firing station, on the day of the blast, some 3,000 ft. away, a dark line surrounding the butte, a contour line denoting the floor of the tunnel. At this elevation, on the southwest side of the butte, was driven a tunnel for a distance of 135 ft., with such angles in its course as to render impossible the blowing out of the charge (see Fig. 1). The inner end of the tunnel was approximately in the center of the butte, and from this end cross-cuts were made for a distance of 35 ft. each way. Here in the cross-piece of the T was stored 32,000 lbs. of black powder, with 144 lbs. of dynamite, distributed as follows: Sections "A" and "B" (see Fig. 2), having 12,000 and 15,000 lbs., respectively, packed solid with bulkheads, "b," of sacks of powder. The remaining part of the T was filled with a solid tamping of rock and earth, except against the west wall, where bags of powder, "E," in all containing 3,000 lbs., were placed. Firing holes were provided, 36 in number ("d"), 5 ft. deep, containing 4 lbs. of dynamite each, with three electric exploders, connected in series, making three circuits, so in case one line should be found open, one of the remaining circuits could be switched on the main firing line. The main tunnel was tamped solid with earth and rock, with bulkheads of green timbers at each angle "c," as in Fig. 2.

The scene from the firing station, 3,000 ft. from the butte, was a grand one. The explosion took place at 2.30 p. m. The word was given by Mr. R. M. Jones, engineer of the Pike's Peak Power Co., and the lever was pressed by Mrs. Woods, wife of Mr. H. E. Woods, manager of the Woods Investment Co., of Victor, Colo. The mountain of rock was hoisted in mid-air, apparently for the moment held trembling in the balance, then fell toward the dam site, the air thick with smoke. It was found later, by actual measurement, that a crater, 72 ft. in depth and 150 ft. in width, had been opened, and 110,000 cu. yds. had been broken, or 80% of the rock above the tunnel level. A view of the butte before the explosion, with the site of the dam in the foreground, is shown by Fig. 3, while Figs. 4 and 5 show the effect of the blast.

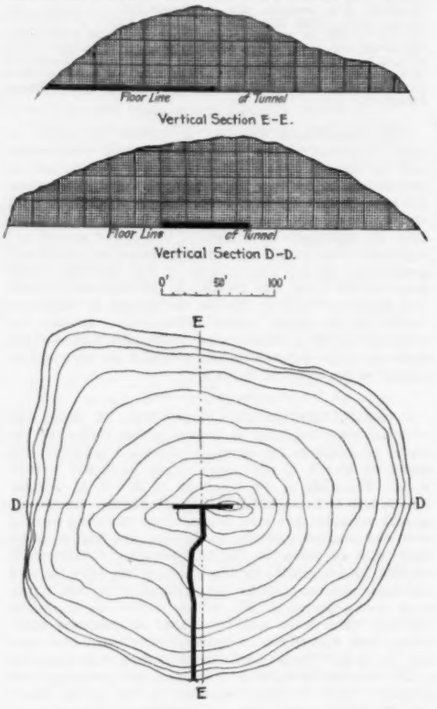


Fig. 1.—Plan and Profiles of Tunnel for Blowing Up Vesuvius Butte.

R. M. Jones, Engineer Pike's Peak Power Co.

A double track railway is now being constructed from the dam to the crater, and also a tunnel through the rim of the crater, at a point near the dam. The terminus of the railway will thus be brought to the center of the crater, and the cars, loaded with rock, will be moved by gravity to the site below.

The dam will be steel-faced, granite-backed, and 69 ft. high, with a width at the base of 125 ft. over a length of 150 ft., and a top width of 16 ft. for a distance of 420 ft. The upper side, being the steel face, is a 30° slope from the vertical. The lower slope is at an angle of 45°.

Water will be conveyed from the dam within one mile of "Power Station A," through a 30-in. steel-banded wood stave pipe, constructed of California redwood. About 20,000 ft. from the dam is Skaguaay tunnel, which is 1,400 ft. in length. The pipe from the dam to the tunnel is laid at a gradient of 1 ft. in 2,000 ft. Just above the tunnel there are many inverted siphons, one of which dips 195 ft. below the surface of the water at the dam. The gradient through the tunnel is 1 ft. in 1,400 ft., being lower in the end nearest the dam. This reversal of ordinary practice is for the purpose of obtaining a discharge overflow by means of a 30-in. stand-pipe, located in, but near, the end of the tunnel most remote from the dam. The stand-pipe reaches an elevation 41 ft. higher than the overflow spillway of the dam and is employed to prevent water ram. The wood pipe extends through the tunnel and down a grade of 35½% until 200 ft. static pressure is reached. Within about 200 ft. of the tunnel, water is conveyed to the station through a steel pipe of 29 ins. outside diameter. The lower section of this pipe is ¾-in. in thickness, this being reduced for each 100-ft. section, upwards, according to the pressure.

At a cost of $300,000 the company will produce 2,000 HP. With a total investment of $450,000, and the possible addition of a small dam, over 5,000 HP. will be delivered about Sept. 1, 1900, to the mines of the Cripple Creek district.

The success of similar plants through the west led to the exploitation of the water of southwest Pike's Peak by the Woods Investment Co., owners and promoters of the Pike's Peak Power Co. The large plants at Ogden and Salt Lake, Utah, were fully investigated and the assistance was secured of the well-known hydraulic electric engineer, Mr. R. M. Jones, of Salt Lake, who had just completed the Big Cottonwood plant, of 2,000 K-W. capacity, and the Jordan Narrows plant, of the same capacity.

The Pike's Peak Power Co. has the advantage of being but nine miles from the center of the Cripple Creek district, loss in transmission thus being cut to a minimum. Prior to starting work the company had pledged contracts, amounting to over 1,500 HP., which ensures the earning capacity of the plant.

THE GATHMANN GUN is not suitable for use on the monitors, says Rear-Admiral O'Neil, of the Ordnance Bureau of the Navy. He objects to the appropriation of $250,000 for putting these guns on some of the old monitors and proposing to throw with them projectiles loaded with 500 lbs. of wet gun-cotton. He says that we have not yet sufficiently developed the art of using high explosives in naval warfare, and if these projectiles are to be useful they must be thrown in quantities, and herein lies the possibility of appalling loss of life and property to the warship carrying such quantities of high explosives. Furthermore, the Gathmann projectiles must carry gun-cotton containing 35% of water, and this materially decreases the effect of the high explosive. The appropriation was struck out before the final passage of the bill in the Senate.

FIG. 3.—VIEW OF DAM SITE, WITH VESUVIUS BUTTE, BEFORE EXPLOSION, IN BACKGROUND.

FIG. 4.—INTERIOR OF CRATER OF VESUVIUS BUTTE AFTER BLAST.

REPORT ON WATER PURIFICATION EXPERIMENTS AT WASHINGTON, D. C.

Nearly a year ago an experimental purification plant was established at Washington, D. C., to investigate the "feasibility and propriety of filtering the water supply of Washington." A brief description of the plant was published in our issue of [illegible], 1899. A report on this investigation, dated March 28, 1900, has just been published.*

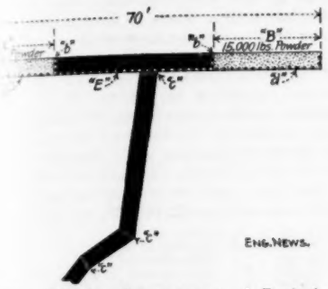


Fig. 2.—Plan Showing Arrangement of Explosives for Vesuvius Butte Blast.

The investigation was conducted by Lieut.-Col. A. M. Miller, M. Am. Soc. C. E., Corps of Engineers, U. S. A., Engineer-in-Charge of the Washington Aqueduct. Col. Miller's report is supplemented by one by Mr. E. D. Hardy, of his office, who had immediate charge of the manipulation of the filters, and by another by Mr. Robt. S. Weston, of Boston, who conducted the chemical and biological examinations after Sept. 11, 1899. Prior to that date, the laboratory was in charge of Mr. Jas. M. Caird. Mr. A. Ross was assistant bacteriologist from Sept. 13 until Nov. 24, after which that position was filled by Mr. Geo. A. Johnson. For some months the laboratory work was limited to quantitative determinations of bacteria, alkalinity, turbidity, and residue on evaporation, samples for bacterial examination (it appears) being collected twice a day, and for the other determinations, once a day. From Oct. 20 to Nov. 27, occasional examinations for intestinal bacteria were made, and beginning with the latter date these examinations were made daily. After Oct. 26, daily chemical examinations were made, using a combination of samples taken simultaneously with the collection of the semi-daily bacterial samples. Besides the laboratory work outlined, recourse was had to some analyses, mostly general, made in other government departments.

The report, in a nutshell, shows that the studies centered around the reduction of bacteria and a most persistent clayey turbidity, both remaining after an average period of subsidence of some 3½ days in the reservoir and aqueduct system of the water-works; that slow sand filtration alone is unable to give a satisfactory water during certain periods; that Col. Miller recommends mechanical filtration; that Mr. Weston believes either mechanical filtration alone or slow sand filtration supplemented by coagulation during periods of turbidity would give satisfactory results, although no experiments with the latter combination were made; and, finally, that the investigation seems to have suffered at a few points through limitations in scope and method. These limitations, presumably, were due to lack of money and time. In the main, they do not materially affect the soundness of the data on which the present or future conclusions are or may be founded, unless it be through the comparative shortness of the investigation, especially in view of the meager laboratory work at the start, and the lack of study of what Mr. Weston, like Mr. Fuller in his Cincinnati report, calls the modified English system, meaning thereby filtration preceded by a period of coagulation. Sedimentation, it must be remembered, is already provided at Washington, and will be increased in duration with the completion of the reservoir now under construction.

*Senate Document No. 259, 56th Congress, 1st Session.

The water supply of Washington is taken from the Potomac River at Great Falls, at a point about 14 miles from the city. The river above the dam has a drainage area of 11,043 sq. miles, on which there is an estimated population of 491,813, or 44.5 per mile. The minimum flow of the river at the dam is 1,065 cu. ft. per sec., or 700,000,000 gallons a day. The average daily flood flow is placed at 6,500,000,000 gallons a day, and the flood flow of 1889 is given as 305,650,000,000 gallons a day. The towns in the drainage area are not provided with sewerage systems, but such qualitative bacterial determinations as have been made indicate a constant pollution by human or animal excreta. Above Harper's Ferry, the drainage area is mountainous, and there being no lakes in the headwater region the river is liable to sudden and heavy freshets. Below Harper's Ferry the drainage area is rolling and cultivated. The stream is placed by Mr. Weston in the clay-bearing class. During dry weather the suspended clay is deposited in a succession of pools along the river, to be washed out by high water.

Fortunately the reservoir and conduit system already in use greatly improve the character of the river water. Thus, from Dec. 2, 1899, to Jan. 17, 1900, the river water, as shown by daily examinations, contained an average of 40 parts per 1,000,000 of suspended matter. After flowing some nine miles through the upper section of the Washington aqueduct, and passing through the Dolecarlia reservoir, which has a storage capacity of 150,000,000 gallons, the suspended matter is reduced to 16 parts, or by 60% of the original. Another stretch of aqueduct, about two miles long, brings the water to a 150,000,000-gallon distributing reservoir, after passing which the suspended matter drops to 13 parts per 1,000,000, a total reduction of 67.5%. The bacterial removal for the period is even more marked, the original number at the dam being 27,000 per cu. cm., which drops to 10,450 after the first reservoir and 5,000 after the second, being reductions of the total by 61.3 and 81.5%, respectively. Marked as is the improvement by sedimentation, it is perhaps less notable than the fact that after a period of subsidence placed at 3½ days, so much clay should still remain in suspension, the clay resisting gravitation much more persistently than the bacteria. The second reservoir, it will be noted, removes only an additional 7.5% of suspended matter, against 20% of bacteria. Moreover, laboratory experiments showed that a further extension of the period of sedimentation would have but little effect on the turbidity.

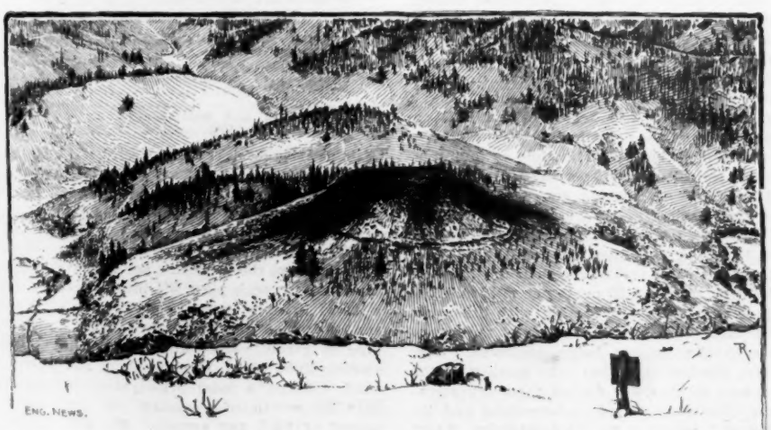


FIG. 5.—VIEW OF VESUVIUS BUTTE, AFTER EXPLOSION, AS SEEN FROM FIRING STATION.

The failure of subsidence alone to clarify the water is better shown by the appearance of the water than by the weight of the suspended particles. Daily records of the appearance of the water at different stages of its progress towards the consumers are available for the 20 years from 1880 to 1899, inclusive. On a scale explained below it appears that during this period the river water at the Great Falls was turbid 53.8% of the time. In 1886, and from 1889 to 1895, inclusive, the receiving or storage reservoir was out of service most of the time.

During the period of one sedimentation, extending over an aggregate of about 8¼ years, the water was turbid 45% of the time; with two sedimentations, extending over some eleven years in all, the turbidity period covered only 35% of the whole time. To be strictly accurate, the 45% for single and 35% for double sedimentation should be compared with the condition of the river water for the corresponding figures, but the report merely gives the turbidity of river water for the full 20 years, which was 53.8% of the time, as already stated. This is not far from correct, for long periods, but for single years there are wide variations. Thus, in 1895, the river water was turbid only 160 days, or 44% of the time. The distributing reservoir, alone, was in service, and the water from it was turbid on 116 days, or 32% of the time. In 1886, the other extreme occurred. There were 238 days of turbidity, at the dam, and 218 at the distributing reservoir, the storage reservoir being out of service; or the raw water was turbid 65% of the time, one reservoir reducing this only 5% more, or to 60%. Coming now to years in which both reservoirs were in service, we find the consumers fared best in 1883, although there were seven years when the river water was better. In 1883 the water at the dam was turbid 56% of the time (a little above the average for the 20 years 1880 to 1899, inclusive). The first reservoir reduced this to 133 days, and the second to 72 days of turbidity, or to 36 and 20%, respectively. The year of worst water, with both reservoirs in service, happens to have been 1899, when the water, after passing through both reservoirs, was still turbid on 185 days, or 51% of the time. The first reservoir gave turbid water on 203 days, or 61% of the time, while the raw water was turbid 64% of the time, or 214 days out of 365.

It will thus be seen that in years of bad raw water two sedimentations not only give a very bad product for the consumers, but the percentage of reduction is so small as to leave no hope for any material gain by increasing the storage capacity. The storage, however, will soon be doubled, by the completion of a 300,000,000-gallon reservoir. With a daily consumption of 60,000,000 gallons, the three reservoirs would afford a supply for ten days, if it could all be utilized. But although the consumption in 1899 was about 50,000,000 gallons, or one-sixth the present storage capacity, the period of subsistence is placed at only 3½ days. To what extent this period will be increased by doubling the storage we cannot say, but it seems as though it should be sufficient to give a total of 5 or 6 days. Colonel Miller, however, credits the new reservoir with a probable average decrease of turbidity of only 2%, bringing it down to 33%, or 122 days in all, as the average for a long term of years.

The turbidity records on which the above figures are based were obtained by noticing the depth at which a small sphere of silver or copper* disappears from view on being sunk in a vessel of water. The water is classed as clear when the disappearance occurs at 36 to 22 ins.; slightly turbid, 21 to 15 ins.; turbid, 14 to 8 ins.; very turbid,

*Given in one part of the report as a 1-in. copper sphere and in another as a 2-in. silver sphere.

7 to 0 ins. In the above discussion all figures less than 22 ins. have been classed as turbid. Mr. Watson assumes a 40-in. vanishing point, for the platinum wire scale (1 mm. in diameter) as a desirable standard. This would be expressed as 0.025.

Coming now to the experiments themselves, we find that they consisted of passing the double-subsided water, after it had flowed from the second reservoir to the Aqueduct Office, through two filters, one an ordinary slow sand filter bed and the other a gravity mechanical filter in which a coagulant was used.

The slow sand filter had an available area of 95,033 sq. ft. The filter bed was composed of a drainage course of 4-in. cobble stones, 8 ins. deep, above which was 4 ins. of 1-in. gravel, 3 ins. of ¼-in. and 3 ins. of 1-16-in. gravel, making 1½ ft. of stone and gravel; above this was 3 ft. of washed Potomac River sand, having an effective size of 0.25 mm. and a uniformity coefficient of 1.8.

The mechanical filter was furnished and erected by the New York Filter Manufacturing Co., and combined the best ideas of the company up to the time of its erection, early in 1899. The effective area of this filter was 28.14 sq. ft. The filtering material consisted of 42 ins. in depth of sand of an effective size of 0.4 mm., and uniformity coefficient of 1.9. Beneath the filter proper there was a coagulant chamber, designed to give the sulphate of alumina an opportunity to decompose and to act upon the raw water before the water reached the filter. The capacity of this coagulated chamber was 2,300 gallons. A sand agitator, or revolving rake, was provided for use when washing the filter.

The slow sand filter was started on June 11, 1899. After getting well started the rate of filtration was maintained at rates ranging from 2,500,000 to 4,000,000 gallons an acre during the various runs between scrapings. The last run covered by the report ended on March 3, 1900. The suspended matter during the first four runs was reduced uniformly to 1 part per 1,000,000, by weight, from originals of 3, 6, 5 and 9; the figures for the fifth run are not given complete, but so far as they go show a reduction of from 21 to 6 parts per 1,000,000. The bacteria during the first run were 346 per cu. cm. in the raw (subsided) water, and 27 in the filtered water, showing a reduction of 86.7%. In the next two runs the initial numbers of bacteria were lower yet, and the removal amounted to about 88½%, with only some 25 bacteria remaining. During the third period the raw water contained an average of 2,940, and the filtered water 122 bacteria per cu. cm., a reduction of 95.8%. For the portion of the fifth run reported there was an average of 8,700 bacteria in the raw and 370 in the filtered water, giving the same percentage of removal as in the fourth run, or 95.8%.

Colonel Miller concludes that slow sand filtration could be relied on to remove 97.8% of the bacteria in the subsided water. If 100 bacteria per cu. cm. were the standard this percentage of reduction would correspond to 4,549 per cu. cm. in the raw water, which is greatly exceeded when the water in question is very turbid. Besides this, evidence of the presence of the bacillus coli communis was found in 25% of the samples of filtered water examined, against 50% in the raw water. It should be noted, however, that regular determinations for this germ (which, by the way, should not be classed as a "disease germ") were not begun until well into the fall, after the raw water had deteriorated in quality.

As to turbidity, the report indicates that slow sand filtration alone would produce unsatisfactory results over longer periods than were shown to be the case with bacteria. This is largely due to the very finely-divided clay particles, which penetrate and pass through the sand filter bed. Mr. Weston states that during 25% of the year slow sand filtration would probably fail to remove the turbidity, even after the settlement effected by three reservoirs.

There does not seem to have been any great trouble with clogging, even though the slow sand filter did fail to remove the turbidity. Colonel Miller estimates that such filters would require scraping about once in 43 days, or nine times a year. Mr. Weston figures on twelve scrapings a year, but this is for what he terms the modified English system, or the use of a coagulant at the subsiding reservoir at times of great turbidity.

The mechanical filter operated at the gross rate of about 130,000,000 gallons an acre. The available yield was reduced by about 3.7% for wash water, or to 125,000,000 gallons a day. It was put in operation on July 18. A strong sulphate of alumina (23.3% available alumina against the usual 17.5%), supplied by the New York Filter Manufacturing Co., was used, varying from 0.6 to 5.84 grains per gallon of water and averaging 1.17 grains. The results obtained were not always satisfactory, but they were better than those from the slow sand filter. There were 26 days when the effluent from the mechanical filter contained over 100 bacteria per cu. cm. to 138 when it contained less, against corresponding figures of 42 and 167 for the slow sand filter. In other words, there was such an excess 1 day in 6.3 for the mechanical and 1 in 5 days for the slow sand filter. The turbidity of the effluent from the two filters was referred to a standard of 0.02 on the platinum scale (wire disappearing at 50 ins. from the surface). On this basis the mechanical filter gave a turbidity of over 0.02 on 19 days and under that figure on 147 days, while the slow sand filter gave corresponding figures of 59 and 177 days. Put differently, the turbidity was above the standard 1 day in every 7.1 for the mechanical and 1 day in every 4 for the slow sand filter. The latter figure is not quite fair to the slow sand filter, since it includes the whole of its first run, unlike the figures for bacteria, but the showing would not be greatly affected if allowance were made for this. It is to be noticed that the turbidity standard is high, being 25% in advance of that recommended by Mr. Weston, but nevertheless it affords a reasonably fair basis of comparison.

Perhaps attention ought to be called to the fact that the turbidity readings with the platinum wire scale were not made directly on the water under observation, but that a very turbid water, called the standard, was prepared by mixing clay with water, until the mixture gave a reading of approximately 0.5 (disappearance of the wire at 2 ins.). Equal quantities of the so-called standard and of the sample in question were then mixed together, the resulting turbidity noted and from twice this figure the turbidity of the standard was deducted. The result was taken to be the turbidity of the sample under observation. The reason given for using this method was that it permitted greater accuracy, particularly as the water increases in clearness. It would be interesting to know what chances of error this method affords. The scale was read with a great degree of refinement, a vernier and tangent screw being used for adjustments.

Mr. Weston states that the coagulating tank "provided for a period of coagulation of from 5 to 15 minutes," and that "coloring material applied to the inlet of the coagulating basin appeared on top of the filter in as short a time as four minutes, when the filter was operating at a rate of about 132,000,000 gallons per acre per day." He believes that a much longer period of coagulation should have been provided, and that the failure to do so "explains to a great degree the poor results" from this filter "when the suspended matter in the influent exceeded 20 parts per million." The words just quoted, in conjunction with others on the same page (111) illustrate some of the inconsistencies in the volume being reviewed. Just above, Mr. Weston says that "the quality of the filtered water at all times during these investigations was admirably suited to household and industrial uses," referring to the mechanical filter; and a few lines further up he says that this filter, or one designed and operated like it, "would fall short of satisfactory efficiency, no matter how much coagulant was added to the effluent."

Colonel Miller closes his report by recommending that mechanical filtration be adopted for the water supply of Washington. He states that for either this system or slow sand filtration a clear water reservoir should be provided, with a capacity of 30,000,000 gallons, which he would effect by partitioning off a portion of the new reservoir, now under construction. He estimates the population to be supplied in 1945 as 600,000. The consumption is already (1899) 178 gallons per capita, but he holds that this might be and ought to be reduced to and held at 100 gallons per capita. Therefore, he bases his estimates on 60,000,000 gallons a day. For slow sand filters he would adopt a rate of filtration of 3,000,000 gallons an acre a day, with an excess of about one-third of area in service held in reserve. He provides in his estimates 27 acres of available filtering service, for which a gross area of about 35 acres would be required at the site proposed, which is close by the new reservoir. The land, selected together with a desire to save masonry, suggests filter beds having an area of about 1.6 acres each. These he proposes to cover. The general design of the filters seems to follow very closely those recently completed at Albany, N. Y. The water must be pumped, regardless of the system of filtration employed. To this end three pumping units of 30,000,000 gallons daily capacity (one in reserve) are provided, the maximum lift to be 30 ft.

The estimated cost of constructing the filter beds and accessories is $2,461,338, divided as follows:

1,111,176 sq. ft. land at 50 cts.		$555,588
731,000 cu. yds. grading at 30 cts.		219,300
139,000 " filter sand at $2		278,000
43,500 " filter gravel at $2		87,000
23,200 " concrete walls at $5.50		127,600
23,700 " " floors at $6		142,200
5,400 sq. yds. flagging for main drains at $2		10,800
85,000 lin. ft. tile drains at 10 cts.		8,500
2,900 tons iron pipe at $30		87,000
Laying iron pipe		29,000
Influent and effluent houses		66,000
Dam for clear water reservoir		80,000
Pumping plant		90,000
Electric light plant		10,000
Laboratory and office		6,000
Sand washers and piping		8,000
Cleaning up		10,000
Covering beds (excluding cost land)		182,100
Engineering and contingencies, 10%		173,250
Total		$2,461,338

The estimates for the mechanical filter plant follow, for the most part, figures supplied by the New York Filter Manufacturing Co., which also made the design shown in the report. A total of 60 units was proposed, each tank to have an effective filter service of 452.39 sq. ft., or 0.0104 acre (diameter = 24 ft.). At a net rate of 120,000,000 gallons an acre a day 48 units in constant operation would be required to yield 60,000,000 gallons each 24 hours; the 60 units, therefore, gives a reserve of twelve, or 25%. The building was designed to accommodate four units more, or 64 in all. Colonel Miller uses 64 units in his resume, but quotes the company's estimated cost for 60 units. The full estimate for mechanical filtration is as follows:

163,430 sq. ft. land at 50 cts.		$81,715
83,500 cu. yds. grading at 30 cts.		25,050
64 filters and auxiliaries	$540,000	
Wash water pump	6,000	
Boilers	9,000	
Engines	1,600	
Steam heating	5,240	
Electric light plant	6,497	
Equipment of engine room	925	
Filter building	178,400	
Conduit	4,100	
Engineering and contingencies on last two items, 10%	18,250	
		770,012
Main pumping plant		90,000
Piping		10,000
Dam for clear water basin		80,000
Laboratory and office		6,000
Engineering and contingencies on last four items, 10%		18,000
Total		$1,081,377

To compare the total cost per 1,000,000 gallons of water under each plan, 3% interest charge is first allowed in each case. Deterioration of the slow sand filtration plant is figured as 5% on cast-iron pipe in place, valves and gates, pumps, boilers, electric light plant, sand washers and piping and sand, making a total principal of $502,000. On $914,200 worth of masonry the depreciation is placed at 1¾% per annum. For the mechanical filtration plant 5% is allowed on the filters and accessories, the main pumping plant and the electric lighting plant, or on $649,262, and 1¾ on the dam, buildings and conduit, or on $288,500. The expense of pumping water to the filters is the same in either case.

The cost of scraping the slow sand filters is put at $34,013 a year, or $3,779 for each of nine scrapings. This is on the basis of labor at 18¾ cts. per hour, and assuming that 1 in. of sand will be removed at each scraping, or 134.54 cu. yds. per acre. It has been found at Albany that this scraping can be done by one man in 67 hours. In addition, this sand must be wheeled out, washed and

which is estimated to require 354, 328.1 man-hours, respectively. This makes a total of 1,007.8 hours per scraping per acre. The cost of superintending the filter beds is \$10,320, for a bacteriologist, watchman, the necessary foremen.

operating the mechanical filter the greatest coagulant. On the basis of 1.3 grains of sulfate of alumina for 21,900,000,000 gallons net 30,000,000 gallons gross (4% for washing), 3,800,000 lbs. would be required. At 1.2 cts per lb. would cost \$50,738.

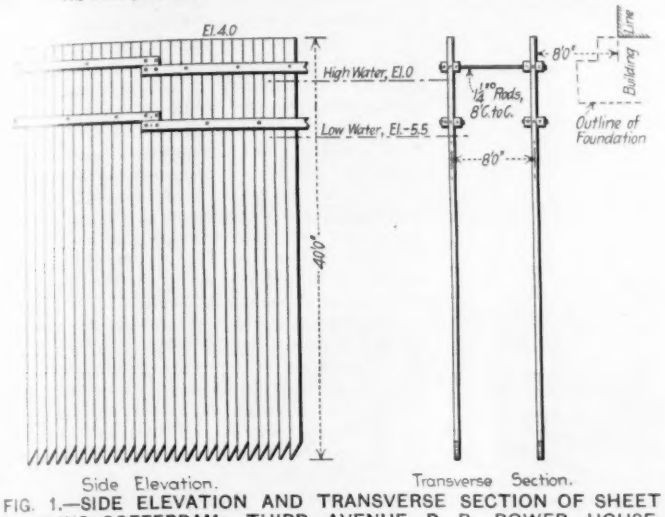


FIG. 1.—SIDE ELEVATION AND TRANSVERSE SECTION OF SHEET PILING COFFERDAM; THIRD AVENUE R. R. POWER HOUSE FOUNDATIONS.

The pay roll for mechanical filtration is estimated as follows:

1 superintendent	\$2,400
1 assistant superintendent	1,800
1 bacteriologist	1,500
1 clerk	900
3 janitors at \$600	1,800
3 filter foremen at \$900	2,700
6 filtermen at \$600	3,600
1 machinist	1,200
1 assistant machinist	600
6 engineers at \$900	5,400
6 firemen at \$720	4,320
Total	\$26,220

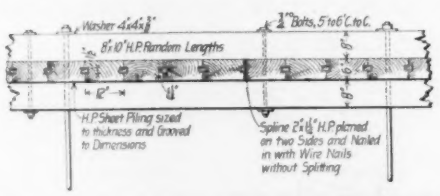

Washer 4"x4"x⅜"
1" Bolts, 5' to 6' C. to C.
6"x10" H.P. Random Lengths
12"
H.P. Sheet Piling sized to thickness and Grooved to Dimensions
Spline 2"x11½" H.P. planed on two Sides and Nailed in with Wire Nails without Splitting

Fig. 2.—Enlarged Top Plan of Sheet Piling; Third Avenue R. R. Power House Foundations.

The items given, and others, for the two systems, are as follows:

	Annual cost. Total. Slow sand.	Annual cost. Total. Mechanical.	Per 1,000,000 gallons. Slow sand.	Per 1,000,000 gallons. Mechanical.
Interest	\$73,840	\$32,441	\$3.37	\$1.48
Depreciation	37,289	36,310	1.70	1.66
Pumping: Raw water.	30,940	30,940	1.41	1.41
Wash water, etc.*	.....	15,000	....	.69
Coagulant	.....	50,758	....	2.32
Superintendence, labor	44,333	26,220	2.02	1.20
Total	\$186,402	\$191,669	\$8.50	\$8.76

*Includes heating, lighting and machinery at filter house.

FOUNDATIONS FOR KINGSBRIDGE POWER STATION FOR THE THIRD AVENUE RAILWAY, NEW YORK CITY.

The superstructure and machinery of the new Kingsbridge power station for the Third Avenue Ry., in New York city, were fully described in our issue of March 22, 1900. In the accompanying illustrations we show the construction of the foundations built to carry this building and plant. Briefly described, this construction consisted simply of a concrete cap carried by piles. The area covered by the power house, as stated in our issue of March 22, is 273 ft. 3 ins. × 216 ft. 4 ins., occupying the city blocks bounded by 218th and 216th streets on the north and south, and by the Harlem River and Ninth Ave. on the east and west. The foundation work, however, actually covered an area of 256 ft. 4 ins. × 319 ft. 9 ins., c. to c. of outer row of piles at the top, and outside of this there came a row of sheet piling 16 ft. distant all around the foundation area.

The borings made at various points over the foundation showed a bed of fine sand overlying solid rock, which was everywhere more than 100 ft. beneath the surface. As the top of the piling came below water level a cofferdam of sheet piling was constructed entirely around the foundation area. Along the east front, and partly along the east halves of the north and south fronts this cofferdam was made of two rows of sheet piling driven 8 ft. apart, as shown by Fig. 1, but elsewhere a single row of sheeting was found sufficient. The double line of sheeting was, in fact, employed only where the cofferdam was open to tide water pressure. Fig. 1 shows a side elevation and cross section of the double line of sheeting and its location in relation to the foundations proper. As will be seen from Fig. 2, which is a top plan of one line of sheeting, the individual piles were grooved on their contact edges and the rectangular holes between piles formed by the two adjacent grooves were filled with close-fitting splines nailed in with wire nails. This sheet piling around the foundations was designed to serve two purposes. Its first purpose was to keep the water, which came in freely through the sand on all sides and brought the sand with it, from the foundation pit, so that the work of excavation, cutting off the piles, and placing the concrete could be done in the open air. Its second purpose was the equally important one of confining the fine sand so that future dredging operations in the river, or excavations for buildings alongside, would not cause the sand to work away gradually from under the concrete cap. When the sheeting was completed the joints between the separate piles were found to be practically water-tight so closely did each pile hug up against the one previously driven.

It will be seen from the plan of the power house published in our issue of March 22, that a row of columns extends lengthwise of the building, and carry a wall separating the boiler-room from the engine and dynamo rooms. The bearing piles were driven 2 ft. 4 ins. apart c. to c. under the boiler-room and 2 ft. 6 ins. apart c. to c. under the engine-room. This spacing refers to all the piles inside the first row around the entire building. The piles in this first row were driven close together, and with a batter outward and downward, this arrangement being adopted to aid the sheet piling in confining the sand, and also to assist in resisting lateral movement for any cause. The inner bearing piles were all driven vertically by water jet except for the last few feet, where they were driven with the hammer only. The maximum load on the piling under the boiler-room was very nearly 14 tons per pile, and on the piling under the engine-room it was about 10 tons per pile, this lighter loading being thought desirable on account of the vibrations liable to be experienced upon this portion.

The partial plan and sections shown by Figs. 3 and 4 illustrate quite clearly the construction just described, and also show the construction of the concrete cap. This concrete cap is everywhere 7 ft. 6 ins. thick, 7 ft. thick above the tops of piles, except near the edges under the outside walls, and under the wall dividing the engine and boiler rooms, where it is 8 ft. thick. This thickness allowed the heads of the piles to be below low water and at the same time carried the floor line just above the highest tides, while giving sufficient vertical depth to distribute any concentrated loads from columns, machinery or smoke-stack over an ample number of piles.

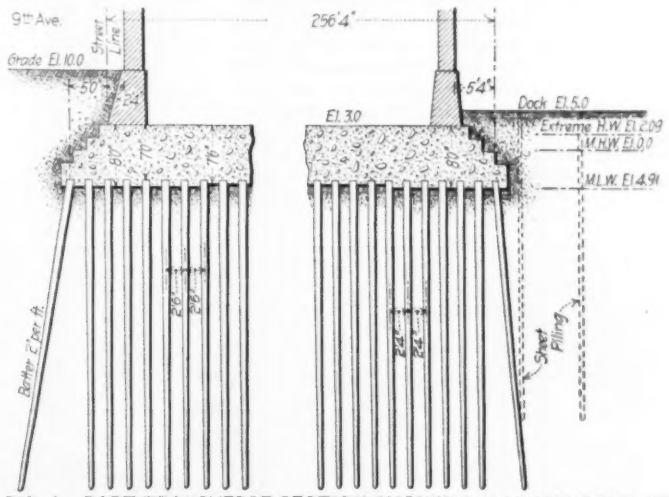


FIG. 4.—PART TRANSVERSE SECTION SHOWING ARRANGEMENT OF PILING; THIRD AVENUE R. R. POWER HOUSE FOUNDATIONS.

Portland cement was employed for the concrete, because of its superior quality to natural cement concrete, and also because it would be permissible with its use to carry on the work in cold weather. The composition adopted was: one part cement, two parts sand, and about four parts broken stone. It was stipulated, however, that in no case should crushed stone be used in such quantities as to produce voids in the concrete. The concrete was deposited in layers which could easily be rammed solid, and the sand underneath was thoroughly rammed previous to depositing the concrete upon it. The drawings, Fig. 4, show the concrete in one solid mass, but in the upper 2 ft. there were really laid quite a number of ducts for wires, and, in the boiler-room, channels for the flow of water to and from the condensers.

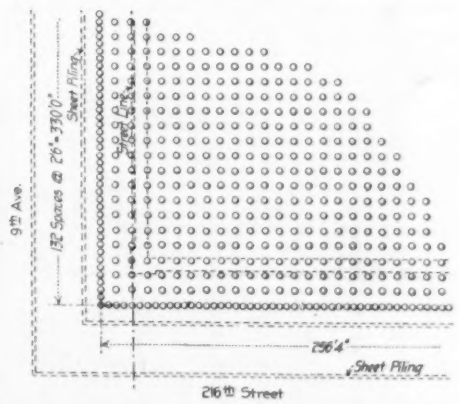


Fig. 3.—Part Plan Showing Arrangement of Piling; Third Avenue R. R. Power House Foundations.

For the information from which this description has been prepared we are indebted to Mr. Geo. B. Francis, M. Am. Soc. C. E., of Providence, R. I., the consulting engineer for the work.

THE THACKERAY GARBAGE FURNACES AT SAN FRANCISCO, CAL.

By F. J. Mills, C. E.

Except for the construction and maintenance of a sewer system, the collection and disposition of the wastes of San Francisco has never been a municipal expense. The dead animals are disposed of by a contract without cost to the city, and the householders have always borne the expense of collecting and disposing of their garbage, ashes and other household refuse. This latter class of wastes, prior to the inauguration of the present system of incineration, was sent to the "dumps," which were located from time to time in such portions of the city as the Superintendent of Streets believed would be the least offensive to the majority of the citizens. But dumping garbage within the city limits had become so offensive to the senses, and so prejudicial to the public health, that a strong agitation for its more sanitary disposal set in, and culminated, in the fall of 1895, at which time the municipal authorities called for bids for the sanitary disposition, for a period of 50 years, of all the garbage, ashes and other house refuse, which, under the terms of the proposed contract, were to be delivered at the works to be provided by the contractor, who was to be allowed to charge the party delivering the same at the rate of 20 cts. per cu. yd.* for the sanitary disposal thereof, the Board of Supervisors agreeing to pass, within its health and police powers, such ordinances as might from time to time be required to compel the householders to send this class of wastes to the contractor, and to pay for the cost of its final disposition, not exceeding the contract price of 20 cts. per cu. yd. So far, therefore, from costing the municipal government anything, the sanitary disposal of the city's wastes was a privilege to be sold to the highest bidder. There were several bids. The successful one, by Mr. F. E. Sharon, was an agreement to pay the city $2,510 in cash upon execution of a contract, and 2% of the gross receipts for the first 15 years of the term, and 5% of the gross receipts for the remaining 35 years. The contract was awarded on this basis Feb. 17, 1896.

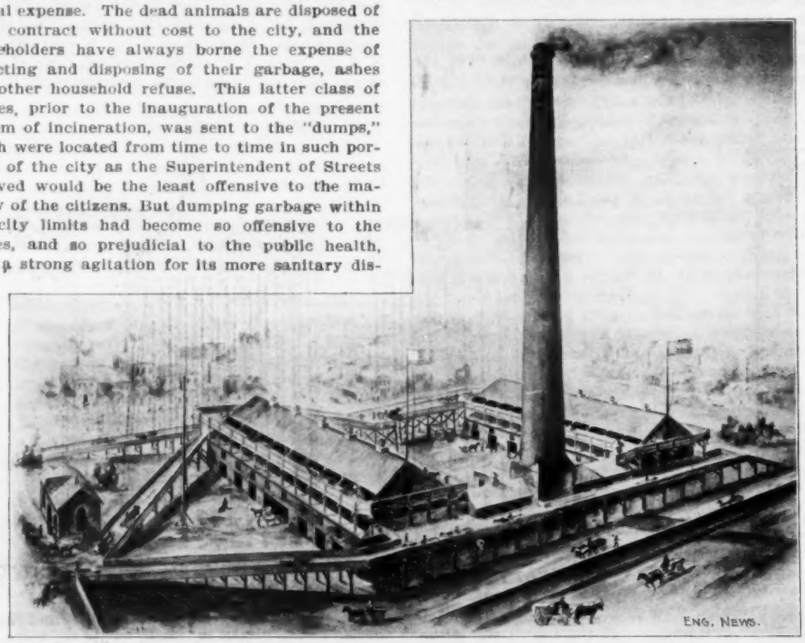


FIG. 1.—GENERAL VIEW OF THACKERAY GARBAGE FURNACES, SAN FRANCISCO, CAL.
Chas. Thackeray & Co., Engineers and Contractors.

Soon after the award of the contract, one of the unsuccessful bidders claimed that he was really the highest bidder, and, therefore, entitled to have the contract awarded to him, and commenced an action in court against the city to that end. The successful bidder intervened in the suit and asked to have the validity of his contract adjudged. The case was tried, and the court held the contract to be within the health and police powers of the Board of Supervisors; that it had been properly awarded, and that it was in all respects a valid and binding contract. Shortly afterwards the Sanitary Reduction Works of San Francisco was incorporated, and Mr. Sharon assigned his contract to that company, which still holds it. Mr. L. R. Ellert, ex-Mayor of San Francisco, was made president of the new company, and was sent East to examine and report upon the various processes used by different Eastern cities for disposing of their garbage and refuse. The first plan of the company was to put up reduction works. [illegible] the very complete and careful examination and report by Mr. Ellert, the Thackeray system of incineration, in use at Montreal, was adopted. [illegible] of low, marshy ground near the old city "dumps" was purchased for the location of the necessary plant, the construction of which was begun in February, 1897. It was constructed under the supervision of Mr. Chas. Thackeray, and completed in the following October, at a cost of about $70,000. A test run of 30 days was then had under the direction of the municipal and health authorities, during which test run an average of about 800 cu. yds. of garbage was disposed of each 24 hours. So very satisfactory was the result of this test that the State Board of Health and the City Board of Health united with the municipal authorities in congratulating the company upon having adopted a thoroughly satisfactory and sanitary process of incineration. The garbage was found to burn clean, and the residuum, ash and clinker to be free from deleterious matter, and the process to dispose of the garbage so as not to be in any way detrimental to the public health."

The garbage, ashes and refuse of San Francisco are mixed by the householders, one receptacle being used for all. The practice of mixing the ashes with the garbage does away with much of the offensive odor from the latter. These wastes have always been collected by private scavengers, mostly Italians, who have formed a "Scavengers' Union." These scavengers did not bid for the contract with the city. They threatened that they would not allow the old system of dumping to be changed, and have bitterly opposed the new system from the start. Upon the opening of the works they refused to bring their collections there, and attempted to continue dumping as before. Many of them were arrested and fined. After this had continued a little while, they commenced bringing their garbage to the company's works, in the meantime having raised the monthly rates to the householders on account of the charge of 20 cts. per cu. yd., which they are obliged to pay upon delivering their loads at the incinerating works. Their next move was to apply for and obtain permission from the Attorney General of the State to commence a suit to declare the contract held by the company null and void, on the ground that the Board of Supervisors had no authority to make such a contract, that the company was charging a higher rate than the contract authorized it to charge, and that the works were being run in a manner which amounted to a public nuisance. The company at once moved to have the Attorney General rescind the leave upon which this suit was instituted, and the case was tried before the Attorney General upon this motion. After investigation the Attorney General held against the petitioner on all of the points, withdrew his leave to commence the suit, and the case was dismissed. Shortly afterwards a man named Vetter, who

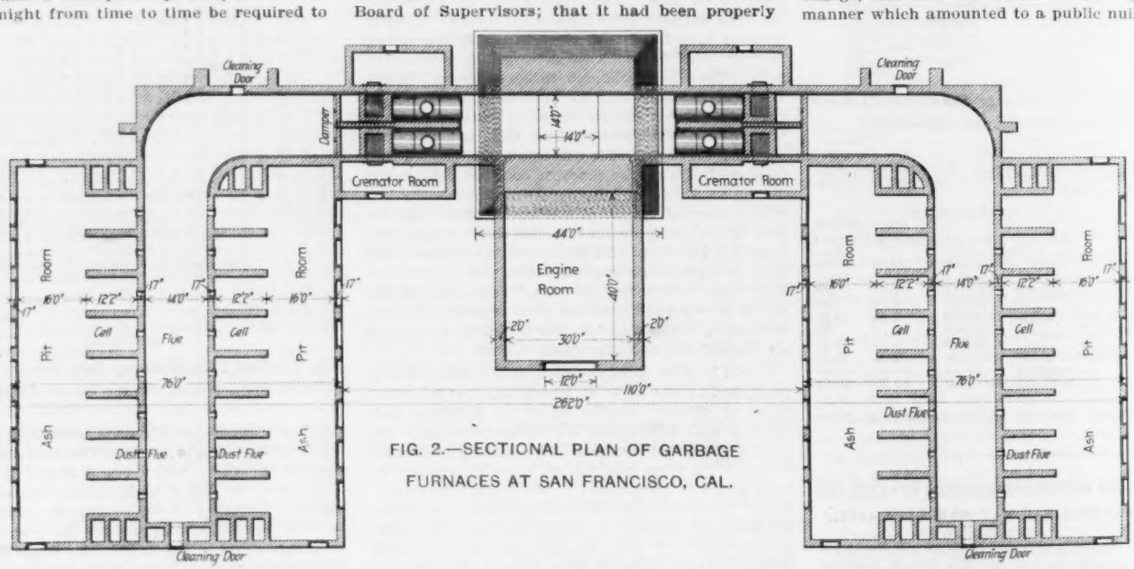


FIG. 2.—SECTIONAL PLAN OF GARBAGE FURNACES AT SAN FRANCISCO, CAL.

*Or more exactly, "not exceeding the sum of 20 cts. per load, such load not to exceed a cubic yard.—Ed.

a half-mile from the works, claimed ..., a young boy, had died by reason of ... poisonous gases contained in the smoke ... works, and brought suit against the com... damages, and to prevent it from oper... plant, on the ground that the works were ... in a manner prejudicial to the pub... Upon the hearing of this application ..., the company claimed that this suit ... at the instance of the scavengers for the purpose of impeding ... in carrying out the terms of its contract with the city, and proved by the physician who attended the boy at the time of his death, that the death was caused by cerebro-spinal meningitis. The company introduced many witnesses residing, doing business or owning property in the vicinity of the works; also some of the leading physicians and chemists of the city, including three out of the four members of the then City Board of Health. Their testimony was to the effect that the gases and vapors escaping from the chimney were non-injurious; that the smoke was less offensive than that from factories in the neighborhood; that the value of property in the immediate vicinity of the works had materially increased since the works had commenced operations; and that a number of factories had erected buildings adjacent to the works since that time. The injunction was refused, and the matter ended. Shortly after this the scavengers attempted to remove the garbage collected by means of boats into an adjoining county. To prevent this, the company applied for an injunction in the United States Circuit Court to prevent the members of the Scavengers' Union from doing anything with the garbage collected by them other than bringing it to the company's works, and paying for its disposal in accordance with the city ordinances and the terms of the contract between the company and the city. This application for injunction was very strongly contested, and the same points were made by the defendants in opposing the application that had been made in the hearing before the Attorney General before mentioned. The injunction was granted, and since then practically all of the garbage and refuse of the city has been brought regularly to the company's works, as provided by the city law.*

*On May 25, 1899, the U. S. Circuit Court granted a preliminary injunction in this case, against the California Reduction Co., which had been removing the garbage from the county. A few days after, the court fixed the indemnity bond of the plaintiffs at $17,500, and emphatically stated that his granting of the preliminary injunction had no bearing upon the merits of the case as a whole, which would be considered in detail on the final hearing. The validity of the franchise, however, appeared to be sustained by the preliminary ruling, even if its exclusiveness were not. Up to April 17, 1900, we are informed by Mr. Mills and also by Mr. R. Brent Mitchell, attorney for the owners of the crematory, this case, which is known as the California Reduction Co. vs. the Sanitary Reduction Works of San Francisco, had not been decided on final hearing. In fact, Mr. Mills states that "no effort seems to be made to get the case up." We also learn through Mr. Mitchell that about 18 months ago a scavenger named G. Valenti was fined $10 in the police court for dumping garbage in the city, instead of taking it to the crematory. On appeal to the Superior Court the attorneys for the scavenger stated that they proposed to test the exclusiveness of the franchise, insisting that it did not prohibit taking garbage outside the county. Judge Cook then stated that he doubted whether the supervisors could prohibit disposal outside the county. The case went over, but has never been heard from since.—Ed.

The plant of the company, located at the intersection of Rhode Island and Alemeda streets, consists of two incinerating houses, with the chimney between, Figs. 1 and 2, together forming three sides of a rectangle about 260 by 100 ft. The incinerating houses are two stories high, and each contains 16 furnaces, or cells (see section, Fig. 3), each having a grate surface 8 × 12 ft., and capable of burning three charges of about 15 cu. yds. of average mixed garbage each per 24 hours, or

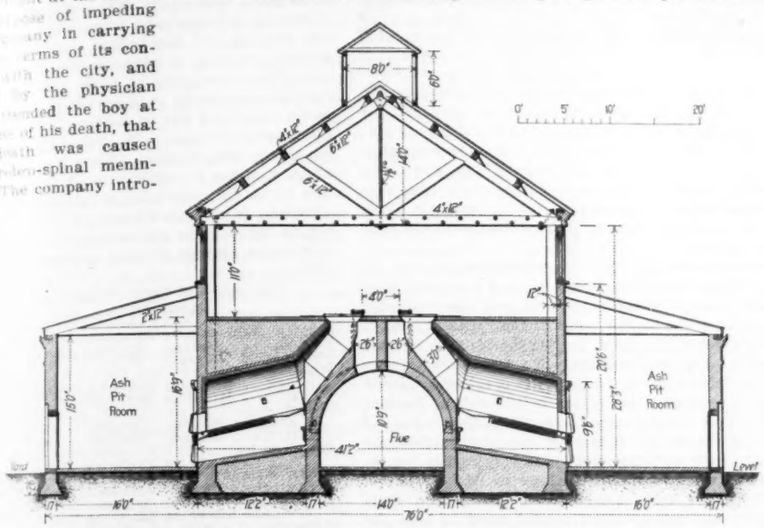


FIG. 3.—CROSS-SECTION OF GARBAGE FURNACES AT SAN FRANCISCO, CAL.

45 cu. yds. per day for each cell. In addition to the 32 large cells, there are four smaller crematory cells located near the chimney. These were designed for the cremation of smoke, but their use for that purpose has not been found necessary. They are not used at all at present, but have a daily capacity of about 30 cu. yds. of garbage each per day. The total capacity of the entire plant, therefore, is not less than 1,500 cu. yds., equivalent to over 600 tons of garbage per 24 hours, making it the largest garbage incinerating plant in the world.*

The cells are constructed upon the same general plan as those of the Montreal plant, described in Engineering News of Nov. 29, 1894. No hot air blast, however, is provided for, the natural draft being found amply sufficient to produce complete incineration. Four boilers were placed in the main flues near the chimney, the idea having been to generate power from the heat of the gases as they escape to the chimney. This feature of the plant, however, is not in use at present, and was evidently not the success anticipated. It is doubtful if much power can be generated from the heat developed by the burning of the garbage unless the boilers are placed adjacent to the cells and utilize the heat from them more directly. The chimney is 265 ft. high, with a 14-ft. flue. The buildings are of brick, with iron roofs, and the whole construction has been of a substantial and practically fireproof character. At the entrance is a small office where measurement is made and cash collected as each wagon load of garbage is admitted. The wagons drive up inclined roadways to the top of the incinerating houses, where they dump into chutes, Fig. 4, leading directly to the hoppers, through which the garbage is fed to the furnaces.

A cell is charged by raking the garbage into the hoppers from the dumping floor, a man at the cell door below at the same time raking it forward into the cell. When filled the cell and hopper together hold about 15 cu. yds. No additional garbage is added after a cell is charged until the material is entirely incinerated and the residuum raked out, enough of the hot clinker being left, however, to ignite the next charge. No fuel of any kind is used. The writer has visited the plant several times and has watched the cells during all stages of the process of incineration, and is fully convinced that the garbage burns clean without the aid of any fuel other than itself. It takes from four to eight hours to each charge, depending upon the character of the garbage, which varies widely, some burning more readily and quickly than others; but the employees all say that they have not yet found any that could not be burned without serious trouble. A little care is exercised when charging a cell to rake the drier and more combustible materials forward on to the hot clinkers to facilitate starting the burning, but aside from this no especial effort is made to separate or to mix the garbage, it being raked into the cells practically as it is dumped from the wagons. The material in the hopper is gradually raked down into the cell as the other is consumed, and dries out a little in the hopper before reaching the fire. A front view of the furnaces is shown by Fig. 5, and Fig. 6 gives the details of the grate bars, both fixed and rocking. Everything that is brought by the scavengers goes into the furnaces, tin cans and metallic substances being about the only exceptions. All articles of any considerable value

FIG. 5.—FRONT VIEW OF FURNACES.

*The blue-prints from which our line illustrations were prepared give the capacity of the 32 cells as 400 tons a day. The small furnaces near the chimney, in the English plants, which this one closely resembles, are known as fume cremators; they burn regular fuel abroad, or did, but appear to be diminishing in favor.—Ed.

are taken out by the scavengers, so there is not much valuable picking for the company at the works. There has never been any screening of ashes, etc., at any time. Everything collected goes in.

As would be expected, there is quite a large quantity of smoke* generated in the burning. It is

Fig. 4.—Dumping Platform and Top of Garbage Chutes.

very light colored and much less offensive than that from the factories using coal for fuel. The writer could not find that there was any special complaint from residents in the vicinity, either on account of the smoke or anything else connected with the operation of the works, the consensus of opinion among those at all familiar with the subject seeming to be that they dispose of the city's refuse in a thoroughly satisfactory and sanitary manner. The writer was surprised, in talking with citizens about the matter, to find how general was the idea that large quantities of fuel were used to effect the incineration.

The total quantity of garbage incinerated since the works commenced regular operations, Nov. 8, 1897, to Jan. 1, 1900, has been as follows:

Nov. 8, 1897, to Dec. 31, 1898.....232,020 cu. yds.
Jan. 1, 1899, to Dec. 31, 1899.....169,201 " "

The decreased quantity for 1899 was due to the fact that all of the garbage collected by the scavengers was not brought to the works during the first part of the year, some of it having been removed out of the county by the California Reduction Co., as before mentioned.

The average quantity of garbage now being delivered at the works is about 650 cu. yds. (say 260 tons) per day,* less than half of their estimated maximum capacity. No force is worked nights. The cells are charged in the evening by the day employees and allowed to burn through the night, being cleaned out and recharged the first thing in the morning. One man only is employed at night. The men work about 11 hours. The total force account at present (March, 1900) is as follows, the prices being per day:

1 foreman	$2.50
1 office man	2.50
1 night man	2.50
5 firemen at $1.75	8.75
5 firemen-helpers, at $1.50	7.50
10 men on garbage floor at $1.62½	16.25
Total	$40.00

Calling the quantity of garbage disposed of 650 cu. yds. (a fair average), the labor expense for its disposal would be a little over 6 cts. per cu. yd., or about 15 cts. per ton. The above labor account does not include the disposal of the ash and clinker, as that expense is a little more than met by the amount received from their sale for filling in purposes on the low ground in the vicinity of the works.

This plant has been in operation nearly 2½ years, and the expense for repairs has been very small, the only repairs having been the replacing of some of the brick linings of the furnaces, an inferior brick evidently having been used in this part of the construction. No insurance is carried. The company has paid no dividends, having been burdened with a considerable floating debt and much expensive litigation, none of which, however, was due to the inefficiency of its plant to do its work, but being rather the result of the peculiar conditions in San Francisco which have been described above. Taken altogether, the unprejudiced verdict must be that the incinerating plant is a success, doing the work for which it was designed in an effective, sanitary and economical manner.

Some experiments have been made with the clinker, which indicate that it can be advantageously used for brick-making and street paving work. It is also expected to eventually utilize the ashes as a base for the manufacture of fertilizer.

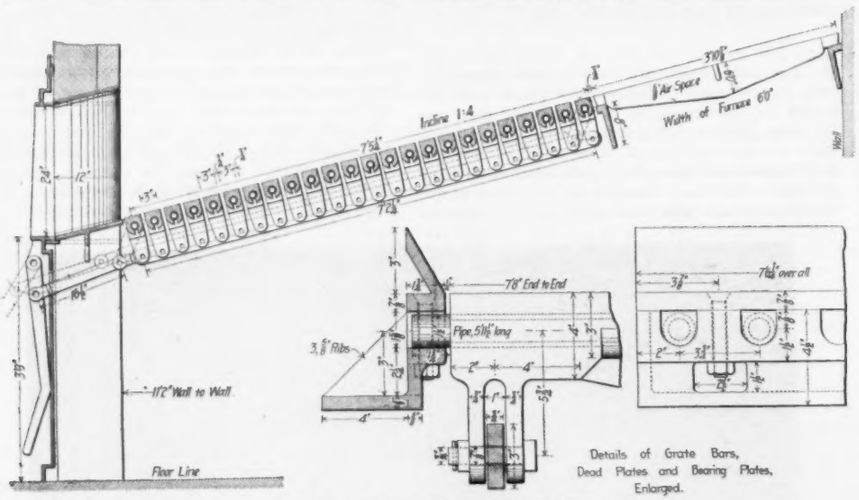


FIG. 6.—DETAILS OF GRATE BARS.

*The owners of the furnace object to the term "smoke" as misleading. They state that during the case of Vetter vs. Sanitary Reduction Works of San Francisco, a leading chemist of San Francisco, named Price, testified that no smoke came from the chimney, as the word smoke is understood in that city. In his affidavit he said: "The process of combustion employed at said works is such that it would be practically impossible for any volatile or obnoxious vapors to escape up the chimney or smokestack of said works, for the reason that all such vapors are completely oxidized in said process of incineration; that the only matters or things escaping from the smokestack of said works are steam, carbonic acid gas and a very small quantity of carbonic oxide."

TWO LARGE CONSOLIDATION LOCOMOTIVES.

(With two-page plate.)

The consolidation type of locomotive is probably the type most extensively used in heavy freight service, and although twelve-wheel engines are also largely used for this service, they are by no means as general as consolidation engines. In our issue of July 27, 1899, we presented the dimensions of a number of large consolidation engines, and in our issue of Oct. 26, 1899, we described and illustrated an enormous twelve-wheel locomotive (the largest and heaviest engine in the world) built for a special class of service on the Illinois Central R. R. A monster consolidation engine has also been built to work in competition with the twelve-wheeler, and the particulars of this engine are given below. These engines, however, are somewhat exceptional in their size and weight, as may readily be imagined when it is stated that they weigh 103½ and 97½ gross tons, respectively. Nevertheless, there is a decided tendency to increase the size and power of freight engines in order to attain the economies due to the handling of heavy train loads. The present condition of freight rates are a very sharp spur towards the adoption of means for obtaining these economies. Only a few months ago the Lehigh Valley R. R. introduced a number of consolidation engines of 77½ tons (Eng. News, July 27, 1899), and in this issue we describe an even heavier engine of 80 tons, which has been put in service on the Cleveland, Cincinnati, Chicago & St. Louis Ry., for hauling its heavy bulk freight. These two consolidation engines, of the Illinois Central R. R. and the C., C., C. & St. L. Ry., afford many points of interest, and may well be compared with one another. The following table gives the leading particulars of the four large engines already mentioned in this article:

Dimensions of Heavy Freight Locomotives.

	Illinois Central Ry.		C., C., C. & St. L. Ry.	Lehigh Valley Ry.
Type	Consolidtn	12-wheel.	Consolidtn	Consolidtn
Builders	Rogers.	Brooks.	Richmond.	Baldwin.
Driving whls.	57 ins.	57 ins.	56 ins.	62 ins.
Wheelbase:				
Driving	16ft. 3ins.	15ft. 9ins.	16ft. 3ins.	16ft. 3ins.
Total	24ft. 5ins.	26ft. 6ins.	24ft. 2ins.	25ft. 5ins.
Weight:				
On drvrs, lbs	198,000	193,200	162,000	175,000
Total, lbs.	218,000	232,200	180,000	175,000
Cylinders, No.	2	2	2	2*
" size	23×30 ins.	23×30 ins.	22×30 ins.	21×30 ins.
Boiler, diam.	6ft. 8ins.	6ft. 10ins.	6 ft.	5ft. 5ins.
W'k'g press.	210 lbs.	210 lbs.	200 lbs.	200 lbs.
Firebox type.	Belpaire.	Belpaire.	Rad'l stay.	Wootten.
" size.	132×42 ins.	132×42 ins.	119×41 ins.	114⅝ x 96"
Tubes, No.	417	424	376	358
" length.	13ft. 8ins.	14' 8⅝"	13ft. 5ins.	15ft. 1in.
Heating surface:				
Tubes	2,951 sq.ft.	3,237 sq.ft.	2,623 sq.ft.	2,810 sq.ft.
Total	3,203 "	3,500 "	2,800 "	2,987 "
Grate area	38.5 "	37.5 "	33.8 "	76.3 "
In Eng. News	Present.	Oct. 26, '99	Present.	July 27,'99

*Also four-cylinder compounds of the same weight.

Consolidation Locomotive; Illinois Central R. R.

As already stated in our columns, this latter engine is experimental to a certain extent, orders having been given to two firms of builders for an engine to meet certain requirements, and having certain specified dimensions. To meet these conditions, the Brooks Locomotive Works adopted the twelve-wheel type, and produced the engine above referred to. The Rogers Locomotive Works, however, adopted the consolidation type, and gave this engine an even greater adhesion weight, with a slightly less total weight. The engine is for service on the main line between Carbondale, Ill., and Fulton, Ky., 98½ miles, where the grades are heavier than on the rest of the line. It is intended to haul trains of 2,000 tons over grades of 0.76%, one of which is seven miles in length.

Fig. 1 is a view of the engine, and Fig. 2 shows the arrangement of the wheelbase, spring rigging, etc. The truck axle has spiral springs in the arms of horseshoe yokes over the boxes, and the truck springs are equalized with those of the front driving axle. The springs of the other three driving axles are connected together in an independent system, but the Lehigh Valley R. R. engines, already referred to, have all the springs connected together in one system. The two front driving axles have semi-elliptic plate springs directly over the boxes, while the two rear axles have yokes or equalizers resting on the boxes and connected to inverted plate springs seated under the top bar of the frame. The back end of the yoke of the trailing axle is attached to an anchor plate held down by spiral springs bolted through the bottom bar of the frame, as shown. Attention may be called to the heavy bars which connect the pedestals, and are bolted to the bottom member of the frame, forming a much more substantial arrangement than the longitudinal bolts usually put through the lower ends of the pedestals, as in the C., C., C. & St. L. Ry. engine, also shown in Fig. 2.

The second pair of driving wheels have blind tires, 6¼ ins. wide, while in the Brooks engine all the wheels are flanged, although the driving wheel base is only 6 ins. less than in the Rogers engine. The distance back to back of wheels is 53⅜ ins. for the flanged tires and 52¾ ins. for the blind

*Working day, or 313 days per year?—Ed.

...ving axles are of nickel steel, and ... are of cast steel, of the form ... 3. The truck axles are of iron. Be... saddle, and between the frames, ... brace, extending 4 ft. 11½ ins. back ... saddle. This casting is bolted to the ... cylinder casting to effect a substantial ... tween them, and relieve the cylinder ... saddle from the severe twisting strains ... are liable to be subjected.

...culdes are used, of case-hardened ... 8 ins. wide on the face and 9½ ins. over ... distance between the faces is 16 ins. ... nickel-steel piston rod is attached to a ...or" crosshead, 24 ins. long on the slid... ... and the cast-steel piston (with cast... ... has a tail rod extending through the ... All the rods are of I-section, while in ... wheel engine the side rods are flat. The ... are of Coffin toughened steel. The third ... is the main driving axle, and carries ... eccentrics, while the link is hung just behind ... axle, as close to it as possible. The ... rods are made as long as possible, but ... the distance between centers of axles ... 5 ft. The link has a radius of 48 ins., ... is stiffened by a rib on its convex face, and ... saddle is formed in two parts bolted to the ... back half of the link. The link hanger is a fork ... or yoke, supporting the link block at both sides ... as is shown in the cross section, Fig. 4. The connection between the link and the rock shaft is effected by a cast-steel yoke embracing the second axle (just forward of the link). This yoke is shown in Fig. 5. It is suspended at (A) from a bracket on a cross brace of the frame, by means of the cast-steel hanger shown, and the end of its stem, at (B), is attached to an arm projecting below the rock shaft. The stem is of I-section, and the yoke itself is double, as shown by the plan. The two sides embrace the link, while the pin (C) passes through the yoke and the link block. The bottom of the yoke is closed by a cast-iron sleeve or thimble, and a 1½-in. through bolt. By this arrangement the pin in the link block, the yoke and the pin in the rock-shaft arm are kept in a direct line, and no bent or curved rods are used.

The boiler is 6 ft. 7¾ ins. diameter at the front, and has a straight-top barrel, while the crown sheet and back of shell slope backward. The barrel is in two rings, with the dome on the second ring. The dome is 30⅞ ins. inside diameter, riveted to the inside of a heavy angle iron ring on the boiler, and the hole in the boiler is 24 ins. diameter. The section at the firebox is somewhat peculiar, as will be seen from Fig. 4. The outside shell is not a vertical surface, as in most Belpaire fireboxes (and on the twelve-wheel engine), but follows the curved contour of the firebox and then turns up to the side of the steam space, making a curious sort of bulge at this point. Horizontal stays with threaded ends pass across the steam space, and the vertical stays consist of eye-bolts or studs in the shell and crown sheet, connected by pairs of flat plates on the pins in the eyes. Certain of the 1-in. staybolts have a 3-16-in. hole drilled to a depth of 1¼ ins. at the outer end.

The smokestack is about 2 ft. 6 ins. high above the smokebox, but projects inside the smokebox, so that its total height is about 3 ft. 9 ins. The exhaust nozzle is about 7 ins. below the center line of the boiler, and above it are two short pieces of pipe forming a petticoat pipe, the lower one 12¾ ins. and the upper one 16 ins. diameter, while the smokestack is about 21 ins. diameter. These pipes are attached to a strap or hanger riveted to the base of the smokestack. The wire netting is horizontal just below the exhaust nozzle, and slopes up to the top row of tubes in the tube sheet and to the front top corner of the smokebox, which is 5 ft. 9½ ins. long. The steam pipes do not follow the curve of the smokebox, but are vertical, with an increased diameter in the top and bottom elbows, as is shown in Fig. 4.

The tender has a frame of white oak, and is mounted on a pair of Fox pressed steel trucks with floating bolsters. The trucks have McKee, Fuller & Co.'s 36-in. wheels, with plate centers and steel tires.

Consolidation Locomotive; C., C., C. & St. L. Ry.

While this engine is not of such enormous weight as the new Illinois Central R. R. engine, it is exceptionally powerful. In fact its cylinders are of the same size as those of the larger engine, and its driving wheels are only 1 in. less in diameter, but it has 36,000 lbs. less weight on the drivers, and weighs 38,000 lbs. less in all. The engine is shown in Fig. 6.

The spring rigging is differently arranged from that of the other engine. The springs of the truck axle and the two front driving axles are all connected by equalizing levers to form one system, while those of the two rear driving axles form an independent system. This is shown in Fig. 2. The second pair of driving wheels have blind tires. Two-bar guides are used, 13 ins. apart between the faces, 3¼ ins. thick and 4 ft. 11¾ ins. long. The piston is fitted with a tail rod.

The connecting and coupling rods are all of I-section, the length of main rods being 9 ft. 8½ ins., c. to c. The arrangement of valve gear is quite different from that of the Illinois Central R. R. engine. The eccentrics are on the third driving axle, but the link is midway between the first and third axles, directly under the rock shaft, and has a radius of 7 ft. 6 ins. In order to pass the second axle, bent or offset eccentric rods are used, as shown in Fig. 2. These rods are of I-section, 4 ins. deep, in order to render them rigid, and prevent any giving or buckling in service. They are shown in detail in Fig. 7. The weight of piston is 293 lbs.; piston rod, 240 lbs.; crosshead, 293 lbs.; main rod, 532 lbs.; side rods, 859 lbs.

The boiler is of the wagon top type, with the top of the shell inclined backwards over the firebox. The dome, 2 ft. 6 ins. diameter, is on the wagon top, just in front of the tube sheet, the hole in the boiler being 2 ft. 6 ins. diameter. The shell around the firebox has a radius of 40 ins., while the firebox has a radius of 33½ ins. for the sides, 84 ins. for the crown sheet, and 15 ins. for the corners. The stay bolts have a 3-16-in. hole drilled in the outside end to a depth of 1¼ ins. Radial sling stays are used, the ends of which are fitted to pins passing through short studs in the shell and crown sheet, as shown in Fig. 8, which shows also a section of the firebox.

The smokebox is 5 ft. 8½ ins. long, with a 16-in. opening for the cylindrical 16-in. smokestack. The exhaust nozzle is just below the center line of the boiler, and above it is the flaring mouth of a petticoat pipe which extends almost up to the base of the stack. The steampipe opening in the tube sheet is 9 ins. diameter.

In the following table the dimensions of these two great engines are given in our standard form:

Dimensions of Consolidation Freight Locomotives.

	Ill. Cent. R. R.	C., C., C. & St. L. Ry.
Running Gear: Driving wheels	4 ft. 9 ins.	4 ft. 8 ins.
Truck wheels	2 " 9 "	2 " 9 "
Tender wheels	3 " 0 "	2 " 9 "
Driving wheel centers	Cast steel.	Cast steel.
Truck wheels	.....	Cast, spoke.
Tender wheels	Steel tire.	Cast, chil'd.
Driving wheel tires	.....	Shrunk on.
Journals, driving axles	9 × 12 ins.	8¾ × 11 ins.
Wheelbase: Driving	16 ft. 3 ins.	16 ft. 3 ins.
Total engine	24 " 5 "	24 " 2 "
Tender	.....	18 " 0 "
Engine and tender	.....	54 " 1¾"
Blind-tired wheels	Second pair.	Second pair.
Length, engine and tender	.....	64 ft. 1½ ins.
Weight in Working Order:		
On driving wheels	198,000 lbs.	162,000 lbs.
On truck wheels	20,000 "	18,000 "
Engine, total	218,000 "	180,000 "
Tender, empty	.....	50,000 "
Tender, loaded	.....	120,000 "
Water in tank	.....	50,000 "
Water in boiler	.....	17,000 "
Coal in tender	.....	20,000 "
Counterbalanced	.....	Assoc. rules
Cylinders	23×30 ins.	22×30 ins.
Form of crosshead	Alligator.	Alligator.
Form of guides	Two-bar.	Two-bar.
Connecting rod, length	.....	9 ft. 8½ ins.
Side rods	Strap ends.	Solid ends.
Valve Gear: Type	Stephenson.	Stephenson.
Ports, steam	1⅝×23 ins.	1¼×20 ins.
Ports, exhaust	3⅛×23 "	2½×20 "
Bridges, width	1⅝ ins.	1¼ ins.
Eccentrics, throw	.....	5 "
Slide valves	.....	Richardson.
Maximum travel	.....	5½ ins.
Inside lap	.....	None.
Outside lap	.....	1 in.
Lead, full forward gear	.....	1/32-in.
Lead, full b'kward gear	.....	1/32-in.
Boiler: Type	Belpaire.	Ex. wgn-tp.
Barrel, diameter	6 ft. 8 ins.	6 ft. 0 ins.
Dome, diameter	2 " 6⅛"	2 " 7⅛"
Barrel plates,	⅝ & 11/16-in.	11/32, ¾-in.*
Smokebox tube plate	⅝-in.	½-in.
Horizontal seams	Sext. riv'ted	Sext. riv'ted
Circumferential seams	Triple riv.	Double riv.
Joints	.....	Lap.
Rivets, diameter	.....	1 in.
Rail to center line	.....	8 ft. 5¾ ins.
Length of smokebox	5 ft. 10 ins.	5 " 8½ "
Smokebox	.....	Assoc. rules
Injectors (2 each)	Nos. 8 and 10 Hancock.	No. 10 Monitor.
Working pressure	210 lbs.	200 lbs.
Firebox: Type	Belpaire.	Radial stay.
Length, inside	11 ft. 0 ins.	9 ft. 11 ins.
Width, inside	3 " 6 "	3 " 5 "
Depth at front	6 " 6 "	6 " 4 "
Depth at back	6 " 3 "	5 " 10 "
Side and back plates	⅝-in.	⅝-in.
Crown plate	11/16-in.	⅜-in.
Tube plate	⅝-in.	½-in.
Crown stays, diameter	.....	1⅛ ins.
Grate bars	Rocking.	Rocking.
Firebrick arch	None.	None.
Staybolts	Drilled.	Drilled.
Diameter	1 in.	⅞, 1, 1⅛"
Pitch	4 ins.	4 ins.
Water spaces, front	4 "	4 "
Back	3½"	4 "
Sides	3½"	3½"
Tubes: Material	Iron.	Iron.
Number	417	376
Thickness	No. 11 W.G.	No. 11 W.G.
Pitch	.....	2.7 ins.
Diameter, outside	2 ins.	2 ins.
Length over plates	13 ft. 8 ins.	13 ft. 5 ins.
Area of tube openings	.....	6.71 sq. ft.
Heating Surface:		
Tubes, interior area	2951.0 sq. ft.	2623.0 sq. ft.
Firebox	252.0 "	177.0 "
Total	3203.0 "	2800.0 "
Grate area	38.5 "	33.88 "
Ratio, heat. surf. to g. area	83.2 to 1	82.6 to 1
Int. tube area to firebox	.....	26.3 " 1
Sq. ft. of total heating surface to 1 cu. ft. cyl. vol.	.....	43.0 " 1
Sq. ft. firebox heating surface to 1 cu.ft. cyl. vol.	.....	1.8 " 1
Sq. ft. tube heating surface to 1 cu.ft. cyl. vol.	.....	40.3 " 1
Sq. ft. grate area to 1 cu. ft. of cyl. vol.	.....	5.2 " 1
Miscellaneous: Exhaust nozzle	Single.	Single.
Exhaust nozzle, diameter	.....	4¼, 5, 5¼"
Smokest'k, diam. top & bot.	.....	1 ft. 3¾ ins.
Height above rail	.....	14' 10¾"
Capacity of tender tank	5,000 galls.	6,000 galls.
Coal space	10 tons.	10 tons.
Brake fittings	Westg.-Am.	West'gh'se.
Tract. force per lb. of eff. press. on piston	278	259
Total tract. force with eff. pres. = 85% boilr press.	49,698	44,078
Total adhesive tract. power at ¼ w't on driv. whls.	49,500	40,500
Ratio of tract. force to w't on driving wheels	25%	27%

*11/16-in. and 9/16-in.

HOT WATER HEATING FROM A CENTRAL STATION.*

By H. T. Yaryan, M. Am. Soc. M. E.†

If some great genius, like an Edison or a Tesla, were to announce to this society that electricity could be produced without cost, I imagine there would be a sensation; and yet the Toledo Heating & Lighting Co. is doing this very thing, as the six months' business ending Jan. 1 last shows, the load being 199 houses heated and 450 lighted.

Receipts from heating	$9,900.88
Receipts from lighting	9,064.78
Fuel	$5,040.63
Wages and salary	2,827.14
Expense (taxes, repairs, oil, waste, etc.)	1,896.77
	$9,764.54

I presume the question will be asked why electricity should be treated as a by-product instead of the heat. My answer is that charges for heat can be fixed and maintained, the consumption of coal increasing proportionately with the number of consumers, while the opposite is true of electricity, and a flexible scale of charges is necessary if the large excess of output is to be disposed of.

The system I am about to describe is so simple that but few words are necessary to make it intelligible. The steam boilers, engines and dynamos are such as may be used in the ordinary electric light station. Heaters of the tubular type, through which the water passes from the pumps to the mains, receive the exhaust steam from the engines, heating the water to any desired temperature. When more exhaust is being produced than is required to heat the water the excess is delivered to a water storage tank to be used later when the output of electricity is small. The circulating system consists of two wrought-iron pipes, laid side by side in the ground, carefully protected by insulation, one pipe for the outflow of hot water impelled by the pumps, the other for the return water from the coils in the various houses heated, going back to the suction end of the pumps, to be forced again through the heaters, where the loss in temperature is restored.

The Toledo Heating & Lighting Co. has two stations, known as the Floyd St. and the Twenty-second St. stations, and although the heating mains of the two stations are separate and distinct, the dynamos of the two stations feed into a common system of electric mains. The length of the double water mains—that is, ditch—connected to the Floyd St. station is 8,550 ft., and the number of houses heated is 101. The length of mains from Twenty-second St. station is 8,260 ft., and the number of houses heated is 98. The amount of radiating surface connected with the Floyd St. station is about 90,000 sq. ft., and with the Twenty-second St. station about 85,000 sq. ft. The amount

*Condensed from a paper presented at the Cincinnati meeting of the American Society of Mechanical Engineers.
†Toledo Heating & Lighting Co., Toledo, O.

raised the total membership to 34. This was also divided into a number of sub-committees, to each of which was allotted the preparing a standard specification upon of steel work. The method adopted by these sub-committees was to collect repre- current specifications, and from these to general or standard specification. When these specifications were discussed and by the whole committee, and it is in this that they are now submitted for general With the aid of the opinions and facts ut by this discussion the American Com- pes to draft a final set of specifications ill fairly represent American practice. al specifications will then be submitted nternational Committee, and, with others by the twelve European Branch Com- will be employed as the basis of the In- al standard specifications which that e will report to the International Asso-

merican Committee submits the specifica- hich it has prepared to engineers with the questions: "Are they fair representatives of specifications in use in America, and of the best American practice?" Arrangements have been made by which the specifications as a whole or in part will be brought up for discussion by the leading national engineering societies of the United States, and it is desired further to obtain expressions of opinion from individual engineers. For this purpose we believe that copies of the various specifications can be procured on application to Prof. J. M. Porter, Lafayette University, Easton, Pa. The following is a reprint nearly in full of the proposed standard specification for Structural Steel for Bridges and Ships:

Process of Manufacture.—Steel shall be made by the open-hearth process.

Chemical Properties.—Each of the three classes of structural steel for bridges and ships shall conform to the following limits in chemical composition:

	Steel: Process— Acid.	Basic.
Phosphorus shall not exceed....	0.08%	0.06%
Sulphur shall not exceed	0.06%	0.06%

Physical Properties.—There shall be three classes of structural steel for bridges and ships, namely: Rivet steel, soft steel and medium steel, which shall conform to the following physical qualities:

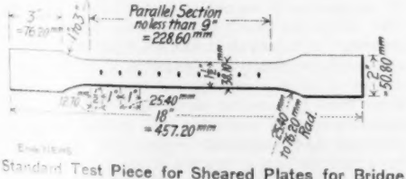
	Lbs. per sq. in.— Tensile strength.	Yield point, not less than.	Elongation in 8″ not less than.
Rivet steel	50,000 to 60,000	30,000	26%
Soft "	52,000 " 62,000	32,000	25%
Medium"	60,000 " 70,000	35,000	22%

For material less than $^5/_{16}$-in. and more than ¾-in. in thickness, the following modifications shall be made in the requirements for elongation: (a) For each increase of ⅛-in. in thickness above ¾-in., a deduction of 1% shall be made from the specified elongation; (b) for each decrease of $^1/_{16}$-in. in thickness below $^5/_{16}$-in., a deduction of 2½% shall be made from the specified elongation; (c) For pins made from any of these three classes of steel, the required elongation shall be 5% less than that specified above, as determined on a test specimen the center of which shall be 1-in. from the surface.

Eye-bars shall be of medium steel. Full-sized test shall show 12½% elongation in 15 ft. of the body of the eye-bar, and the tensile strength shall not be less than 55,000 lbs. per sq. in. Eye-bars shall be required to break in the body, but should an eye-bar break in the head, and show 12½% elongation in 15 ft. and the tensile strength specified, it shall not be cause for rejection, provided that not more than one-third of the total number of eye-bars tested break in the head.

The three classes of structural steel for bridges and ships shall conform to the following bending tests; and for this purpose the test specimen shall be 1½ ins. wide, if possible, and for all material ¾-in. or less in thickness the test specimen shall be of the same thickness as that of the finished material from which it is cut, but for material more than ¾-in. thick the bending test specimen may be ½-in. thick.

Rivet rounds shall be tested of full size as rolled. (d) Rivet steel shall bend cold 180° flat on itself without fracture on the outside of the bent portion; (e) Soft steel shall bend cold 180° flat on itself without fracture on the outside of the bent portion; (f) Medium steel shall bend cold 180° around a diameter equal to the thickness of the specimen tested, without fracture on the outside of the bent portion.



Standard Test Piece for Sheared Plates for Bridge and Ship Work.

Test Pieces and Methods of Testing.—The standard test specimen of 8-in. gaged length shall be used to determine the physical properties specified above. The standard shape of the test specimen for sheared plates shall be as shown by the accompanying sketch.

For other material the test specimen may be the same as for sheared plates, or it may be planed or turned parallel throughout its entire length and in all cases where possible, two opposite sides of the test specimens shall be the rolled surfaces. Rivet rounds and small rolled bars shall be tested of full size as rolled.

One tensile test specimen shall be taken from the finished material of each melt, but in case this develops flaws or breaks outside the middle third of its gaged length, it may be discarded and another test specimen substituted therefor.

One test specimen for bending shall be taken from the finished material of each melt as it comes from the rolls, and for material ¾-in. and less in thickness this specimen shall have the natural rolled surface on two opposite sides. The bending test specimen shall be 1½ ins. wide, if possible, and for material more than ¾-in. thick the bending test specimen may be ½-in. thick.

The bending test may be made by pressure or by blows. Material which is to be used without annealing or further treatment shall be tested for tensile strength in the condition in which it coses from the rolls. For material which is to be annealed or otherwise treated before use, a full-sized section of tensile test specimen length, shall be similarly treated before cutting the tensile test specimen therefrom.

For the purpose of this specification, the yield point shall be determined by the careful observation of the drop of the beam or halt in the gage of the testing machine.

In order to determine if the material conforms to the chemical limitations prescribed, analysis shall be made of drillings taken from a small test ingot.

Variation in Weight.—The variation in cross-section or weight of more than 2½% from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations: (h) Plates 12½ lbs. per sq. ft. or heavier, when ordered to weight, shall not average more than 2½% variation above or 2½% below the theoretical weight. (i) Plates under 12½ lbs. per sq. ft., when ordered to weight, shall not average a greater variation than the following: Up to 75 ins. wide, 2½% above, or 2½% below the theoretical weight; 75 ins. and over, 5% above or 5% below the theoretical weight. (j) For all plates ordered to gage, there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

Table of Allowances for Overweight for Rectangular Plates When Ordered to Gage.

(The weight of 1 cu. in. of rolled steel is assumed to be 0.2833 lb.)

Plate ¼-in. and Over in Thickness.

Thickness of plate.	Width of plate.— Up to 75 ins.	75 to 100 ins.	Over 100 ins.
¼-in.	10%	14%	18%
$^5/_{16}$-in.	8%	12%	16%
⅜-in.	7%	10%	13%
$^7/_{16}$-in.	6%	8%	10%
½-in.	5%	7%	9%
$^9/_{16}$-in.	4½%	6½%	8½%
⅝-in.	4%	6%	8%
Over ⅝-in.	3½%	5%	6½%

Plates Under ¼-in. in Thickness.

Thickness of plate, in.	Width of plate.— Up to 50 ins.	50 ins. & above.
¼ up to $^5/_{32}$	10%	15%
$^5/_{32}$ " $^3/_{16}$	8½%	12½%
$^3/_{16}$ " ¼	7%	10%

Finish.—Finished material must be free from injurious seams, flaws or cracks, and have a workmanlike finish.

Branding.—Every finished piece of steel shall be stamped with the melt number, and steel for pins shall have the melt number stamped on the ends. Rivets and lacing steel, and small pieces for pin plates and stiffeners, may be shipped in bundles, securely wired together, with the melt number on a metal tag attached.

Inspection.—The inspector representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment.

STEEL HOSE-ARMOR AND HOSE COUPLING.

Rubber hose used to carry compressed air, steam or water under pressure for power purposes, is liable to be kinked or bruised in handling, and its tendency to burst is thus increased. In order to prevent this, a style of hose has been devised

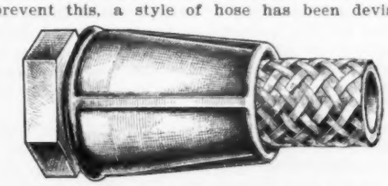


Fig. 1.—Armored Hose with Climax Coupling.

which is wrapped by two thin flat steel bands, about ⅛-in. wide, wound spirally in opposite directions and woven together to form a flexible protective covering, as shown in Fig. 1. A difficulty at first experienced with this hose-armor was that of holding it securely at the ends of the length of hose so as to prevent slipping. This has been overcome by the Climax coupling, a section of which is shown in Fig. 2. The end of the rubber hose is clamped in a conical casting (A), on the outside of which are laid the ends of the steel bands, and over this is fitted the conical sleeve (B), which grips the bands. By screwing down the nut (C) the sleeve (B) is drawn up on the casting (A), thus tightening the grip on the bands. In case of the hose being submitted to high pressure the tendency is to force the armor out, which would pull down the casting (A) and simply tighten the grip.

Where rubber hose is used under pressure, it must generally be of heavy weight, and even then its life is short. It is claimed that a lighter hose with this armor will stand higher pressure and last longer than more expensive hose. A piece of two-ply hose fitted with the armor has been tested to a pressure of 1,800 lbs. per sq. in. without failure. The armored hose is manufactured by the Metallic Flexible Tubing Co., of Philadelphia, and the Climax coupling is the invention of Mr. F. G.

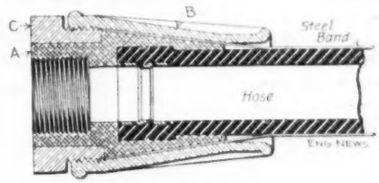


Fig. 2.—Section of Climax Coupling for Armored Hose.

Street, 509 Temple Court Building, Chicago, whose specialties include the hose and coupling, and to whom we are indebted for information. The armor gives a smooth surface, and for suction hose it can be applied on the inside as well as the outside. It can be applied to hose already in use. The coupling can also be applied to any hose by means of a suitable expander designed by Mr. Street, in which the mandrel is expanded by a taper stud on the end of a capstan-headed screw. This expands the hose into the groove of the conical casting, as shown in Fig. 2.

We are informed that both the armored hose and the hose coupling are largely used in the U. S. navy yards, in locomotive and bridge shops, and by mining and railway companies, etc. They are also considered to be well adapted for air brake and steam heating connections on railway trains, and it is intended to push their introduction in this service.

TRAFFIC DEVELOPMENT ON THE KIEL SHIP CANAL.

Late official reports give considerable detail touching the development of traffic on the North Sea and Baltic, or Kiel Ship Canal. Two tables show the number of ships passing through the canal in the years 1895, 1896, 1897 and 1898, and their respective tonnage and means of propulsion.

The number of vessels using the canal, in 1895, was 16,834, divided into 7,531 steamships and 9,303 sailing vessels. In 1898 the total had increased to 25,816 vessels, with 11,005 propelled by steam, and 14,811 by sails. In 1896 the total tonnage was 1,848,858 tons, or 1,407,435 tons steam, and 441,623 tons for sailing vessels. In 1898 the total tonnage was 3,117,840 tons, of which 2,467,839 tons represented steam and 650,001 tons, sailing ships.

The canal is 58 miles long, with tidal locks only, at the two extremities. In 1897 the average time of transit through the canal was 8 h. 36 m., as compared with 9 h. 33 m. in 1896. The mean speed of steam vessels, drawing 16.4 ft. of water, was thus about 8 miles per hour; and for larger vessels it was 6.9 miles per hour. The average time consumed in passing the locks, was 8.8 m., at Holtenau, on the Baltic side, and 17.1 m. at Brunsbuttel, on the North Sea side. In the year 1898, the mean time for passing the canal, for vessels drawing 17.7 ft. of water, was 8 h. 48 m.; this loss of time of 12 m. was due to the sinking of the ship "Trygg," causing an obstruction in the channel; and also to the creation of a new passing station.

In 1896 the total receipts from the canal amounted to 1,016,854 marks, and the expenses were 2,074,792 marks. In 1897, the receipts increased by 283,490 marks; but the expenses increased 203,490 marks, due to new equipment and the improvement of the channel. During 1898 the total receipts were 1,634,337 marks, and the expenses were 2,066,737 marks, representing an increase of 25.72% in receipts over the previous year, and a diminution of 9.3% in expenses. In brief, while the traffic is slowly increasing, the canal was not yet paying its operating expenses in 1898.

of coal consumed at both stations during the heating season, from October 1 to May 1, averages 5,000 short tons of coarse slack, or about 25 tons to the residence. These same buildings, if heated by their own furnaces, would average not more than 18 tons of hard coal each. The difference may be accounted for by the loss of heat in ground radiation, and largely by the fact that we heat the buildings more thoroughly and for a greater number of hours than they could or would do by private furnaces. The loss of heat through radiation in our mains is an important one, and I am sorry not to be able to give positive data, but it is impossible more than to approximate the loss. From careful observation I estimate the loss to be between 15% and 20%. The water reaches the extreme end of our lines, three-quarters of a mile from the station, in the coldest weather, with a loss of 12° F., which would be an average of 6° to all of the houses. As the water returns to the station with a drop of 35°, this would indicate about 17% loss in the ground, which I believe to be nearly correct. A pressure of 60 lbs. is maintained on the feed line during cold weather and 40 lbs. during moderate weather. The service pipes to the various houses are 1-in. pipe, and the return line throttled with a disk inside the building, the size of opening depending upon the quantity of radiation, but average ⅝-in. The houses are equipped with radiation sufficient to heat them to a temperature of 70° F., with water entering the house at 160° F., when the outside temperature is freezing. By raising or lowering the temperature of water 1° for each degree of variation in the outside temperature we are able to maintain a constant temperature in the houses during all kinds of weather. There is no occasion for the consumer to regulate the flow of water during the entire winter, and with few exceptions our consumers open the supply valves in the fall and only close them in the spring. The extreme limits of temperature of the water is from 130° in moderate weather to 212° in the coldest.

Insulation.

The insulation used is shown in section herewith, and is both effective and inexpensive. The top, bottom and sides are made in separate sections by using for top and bottom three 1-in. boards, separated with ½-in. strips to form air spaces, with 1-in. × 4-in. boards on the sides to prevent the entrance of earth. This manner of insulation is as near perfect as can be hoped for, and the only improvement which might be suggested is to creosote the outside boards. After four years of use the only sign of rotting is in the outside boards which come in contact with the earth. The heat in the mains keep all other boards perfectly dry, and it would seem that their life was indefinite. The mains are laid in a ditch only 30 ins. deep, as we have found by experience that the nearer they are to the surface of ground the less loss by radiation. The reason for this is

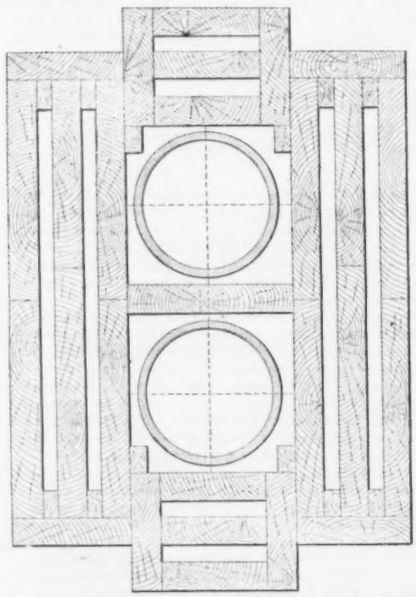


Fig. 1.—Heat Insulation for Hot-Water Distribution Mains; Toledo Heating and Lighting Co.

simple enough, as wet ground is a better conductor of heat than dry, and the deeper you go the longer the ground remains wet.

Heaters.

The heaters are really surface condensers, and I have some hundreds in use for this purpose, the only novelty about them being the manner of providing for the difference in expansion of copper tubes and iron shell. No thimbles or other devices are used to permit a slip through flue sheets, but each tube is rigidly expanded in the top and bottom flue sheet. They are 7 ft. long, 24 ins. in diameter and contain 500 ⅝-in. copper tubes. The tube before entering is bent so as to make a permanent sag of ⅝-in., which is intensified to about ¾-in. in expanding, by the use of a drift.

Grease Traps.

As all the water of condensation is sent back to the boilers, a thorough separation of oil is necessary. I have found most of the so-called traps a delusion, as they depend upon slowing down the steam current to permit the particles of oil to be dropped. The finer particles, however, are so thoroughly entrained that they are carried to the condensers and thence to the boilers. The trap shown in Fig. 2 was really constructed to separate entrained salt water in distillers on shipboard under a vacuum, where the speed of vapor is high. The principle involved is separating the volume of vapor into jets by passing through 1-in. tubes equal in area to the exhaust pipe, so that only a narrow space intervenes between the end of tube and impinging surface. The smallest particle of entrained substance is carried over this space by its own momentum, and is held by the impinging surface, where it runs off through the drain pipe. Incidentally, I may state that fully one-half of the oil used on engines and pumps is recovered and used over again.

Expansion on Mains.

The provision for expansion on underground mains is of vital importance. After trying all manner of devices the ordinary U, where the run is straight, and 90° bends at

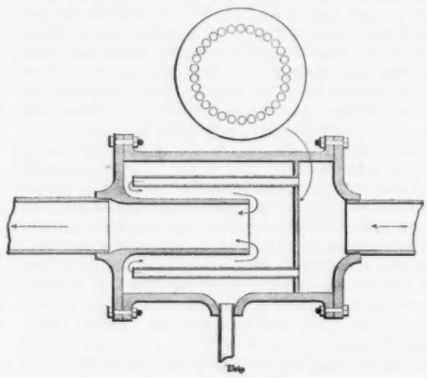


Fig. 2.—Grease Separator for Exhaust Steam; Toledo Heating & Lighting Co.

corners, answer the purpose admirably and give no trouble whatever. The Us are placed about 600 ft. apart, and as the extreme expansion is about ¾-in. to 100 ft., only 4½ ins. are necessary to be taken care of by each U. As the mains are laid cold, we put an extra strain when laying on the Us in an opposite direction to that in which they work when allowing for expansion.

Corrosion of Mains.

Almost the first question asked by a practical engineer is, How about the corrosion of your pipes? I am happy to say that I can answer this question in a satisfactory manner, as over 10,000 ft. of pipe were relaid last summer, after being in use five years. The wrought-iron pipe showed no signs whatever of corrosion, but steel pipe was perceptibly affected. There was a great difference in different lengths of steel pipe, but all were affected more or less. The appearance of the pipe showed the formation of nodules on the inside, varying in number from one dozen to 100 in a length of pipe and in size from a grain of corn to a hazel nut. When the nodules were removed a soft underlayer of carbon remained, and with the finger nail this could be removed, developing a perfectly round pit from ¼ to 3-16 in. deep, but in no instance had the pit perforated the pipe. As a matter of curiosity, some steel pipe which had been in use two years was examined and found to be in exactly the same condition as that of five years' use. The action seems to be electrolytic, some particle of impurity forming the nucleus for decomposition of the steel. If any inference can be drawn from the facts stated, it is that the impurity has lost its power to cause electrolysis after being surrounded by a sufficient amount of graphite. The most important lesson taught, however, is that only wrought pipes should be used for water circulation.

Friction Loss in Mains.

In calculating the size of mains for a given number of houses it became necessary to know the relative friction of hot water as compared to cold. To my surprise I was unable to find any data that were of value, and to settle the question I made some tests which may be useful in future work. A run of 450 ft. of 1-in. wrought-iron pipe, with numerous bends, was connected to a heater and the water passed through a meter. With a constant pressure of 10 lbs., the following cubic feet of water were delivered at the open end of the line in five minutes:

At 34° F.	6.2	At 150° F.	6.6
" 60° "	6.2	" 185° "	6.75
" 90° "	6.4	" 212° "	7.9
" 120° "	6.5		

Steam vs. Hot Water.

As exhaust steam heating from central stations has been introduced to a limited extent, it may not be out of place to call attention to the objections to steam, which do not apply to hot water.

1. The exhaust not being uniform in power plants throughout the entire period of 24 hours, either live steam must be used during the minimum load or exhaust must be lost during the maximum load.

2. The excessive cost of laying steam mains, which must be large and thoroughly protected from the water. The temperature of pipes being above the boiling point of water, any infiltration of water is converted into steam, and thus a vast amount of heat is dissipated.

3. It is absolutely necessary that from 5 to 10 lbs. back pressure shall be carried on the engine, which is exceedingly wasteful.

4. The condensation of steam is wasteful, as with it a large percentage of heat.

5. The piping of houses is expensive on account of the large size required to convey steam with 1 or 2 lbs. back pressure.

6. The service is not satisfactory on account of difficulty in regulation, especially in mild weather.

7. The offensive smell, due to vents and leaky stuffing boxes.

8. Water hammer, due to condensation in horizontal pipes.

9. The quality of heat, especially where direct radiation is used.

10. Danger from fire, which has been abundantly demonstrated, can arise from long continued contact of steam pipes with wood in an inclosed place.

11. Greater loss by radiation in ground, due to an average higher temperature of mains.

12. The necessity for sewer connections to remove condensation in mains where traps may form.

13. The rapid destruction of all iron drips, due to the solvent action of distilled water.

14. The filling of the entire system with air when a shut down occurs for any length of time.

The only counter charge I have ever heard made was that it required live steam to run the pumps. But this is largely offset by the back pressure on engines in the steam system, and can be made a large source of profit by selling the heat, as none is wasted.

During the past two years the system I have described has been installed and is now in successful operation in the following cities and towns: La Porte, Ind.; Mattoon, Ill.; La Crosse, Wis.; Kenosha, Wis.; Alton, Ill.; Portage, Wis.; Boone, Perry, Ida Grove, Iowa Falls and Mason City, Iowa.

During the present summer the company which I represent will install a refrigerating plant for domestic use, distributing cold brine in exactly the same manner that we do hot water, but using a separate set of mains. We shall use an ammonia-absorption machine, operated with exhaust steam, so that as the demand for heat ceases that for cooling purposes begins, thus utilizing the exhaust steam from our engines during the summer months, which now goes to waste.

STANDARD AMERICAN SPECIFICATIONS FOR IRON AND STEEL.

The task of preparing a series of specifications for iron and steel which would represent fairly the best American engineering practice, as many of our readers know, was placed in the hands of a special committee of the American Section of the International Association for Testing Materials at its annual meeting held in August, 1899. This committee has just made public the results of its work in the form of a report of its proceedings and sets of standard specifications, as follows: (1) Structural Steel for Bridges and Ships; (2) Structural Steel for Buildings; (3) Steel for Rails; (4) Open-Hearth Boiler Plate and Rivet Steel; (5) Steel Castings; (6) Steel Splice Bars; (7) Steel Axles; (8) Steel Tires; (9) Wrought Iron; and (10) Steel Forgings. These several specifications as at present adopted are tentative only, and are submitted now in order to obtain a discussion of their provisions, which will enable a final draft of each to be prepared for presentation to the Association for final discussion and adoption at the annual meeting in October.

The committee appointed in August, 1899, as noted above, forms the American Branch of Committee No. I., "On International Rules and Specifications for Testing and Inspecting Iron and Steel," of the International Association for Testing Materials. As appointed the committee consisted of five members, but it was given power to increase its membership to such a number as it chose. Advantage was taken of this privilege by the committee, which at its first meeting voted to increase its membership to 20 by the addition of 15 new members. Subsequent additions of mem-

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In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 320 *means that subscription is paid to the* 32*d week (that is the issue of Aug.* 9) *of the year* 1900; *the change of these figures is the only receipt sent, unless by special request.*

ADVERTISING RATES: 20 *cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

As a result of the recent discussion over armor plate and its price, in the U. S. Senate, there have been various mis-statements in the public press regarding the wonderful penetrating power of "a new projectile"—a soft steel-capped armor-piercing shell. We are told that it has lately passed "clean through" 14 ins. of Harveyized steel, and a 6-in. projectile of this type has perforated an 8-in. Krupp armor plate. The first statement is not true, inasmuch as the shell penetrated 14 ins. into the Harveyized plate, with the point just appearing at the back; and the perforation of the Krupp plate was due to an increase in the velocity of the projectile from 2,300 ft. to 2,580 ft. per second, rather than to any change in the projectile. The fact of the matter is that this capped projectile is not new; our battleships were supplied with them in the Spanish-American war, and Russia and our own Navy Department have been experimenting with them for several years.

The practical failure of the earlier experiments was due to the inherent difficulty of so attaching the soft steel cap to the projectile that it would perform the duty expected from it. It was this difficulty that was overcome by the late Isaac G. Johnson, of Spuyten Duyvil, N. Y., whose soft steel capped shells have successfully withstood the government tests and proved their powers of penetration.

In this connection an interesting story is told of the incident which first induced Mr. Johnson to turn his attention to the use of capped projectiles against armor plate. He was then manufacturing chilled cast-steel shells for the government and was present at a test of these shells at Indian Head. Two exactly similar targets were in position, but the one not to be tested at that time was covered by a boiler plate screen. The target fired at had smashed all the projectiles delivered against it, when, by a mistake of the gunner, one of the same shells struck the screened target, and to the surprise of those present it passed clear through this target. Mr. Johnson was quick to notice that the result was due to the intervention of the boiler plate, acting as a cap and lubricant, and protecting the point of the shell against initial destruction by the hard face of the target. He at once studied the trials and failures of previous experimenters and evolved the capped shell now bearing his name.

The action of this soft cap in enabling a projectile to penetrate armor is explained as follows: The sudden stoppage against the hard face of the armor of a projectile, delivered at a velocity of nearly 2,600 ft. per second, evolves intense heat, weakens the point of the projectile, and, at times, actually melts it, as is shown by a ring of melted metal at the point of impact. The office of the cap is to take up this heat and work, and to thus leave the point of the projectile practically intact and in a condition to exert all its force in overcoming the resistance of the plate. The cap, by welding itself to the face of the armor, also acts as a guide and support to the point of the projectile; and the softer metal serves as a lubricant. It is also argued that the welded cap-metal largely overcomes the tendency of the point to glance, when the line of fire is somewhat oblique to the face of the armor plate. As may well be imagined, the effectiveness of the cap largely depends upon the manner in which it is attached to the point of the shell; and it is in this particular that American ingenuity has achieved a success that was nowhere else attained.

The report on water purification experiments at Washington, D. C., abstracted elsewhere in this issue, adds one more to the list of valuable contributions to the literature of water filtration, which have recently been made.

Doubtless all will agree that the capitol city of the United States ought to be furnished with the best water supply that American engineering talent can provide. This is far from being the case at present; and it is to be hoped the investigation recorded in Col. Miller's report may result eventually in the carrying out at Washington of a model water purification plant for the city's supply.

If the report of the Washington experiments is not in all respects as complete and satisfactory as might be desired, it can doubtless be ascribed to the limited appropriation which was available for the work. It certainly answers in the affirmative, however, the question implied by the title of the report, "Feasibility and Propriety of Filtering the Water Supply of Washington, D. C."

As to whether mechanical filtration along the lines recommended is the best means of improving the quality of the Washington water, the report is hardly convincing. There is little doubt but that the proposed plan, with some modifications, will give a very satisfactory water, but it is by no means certain, from the evidence presented, that equally good results might not be obtained by a combination of storage, subsidence and slow sand filtration, with coagulation at certain periods of very bad water.

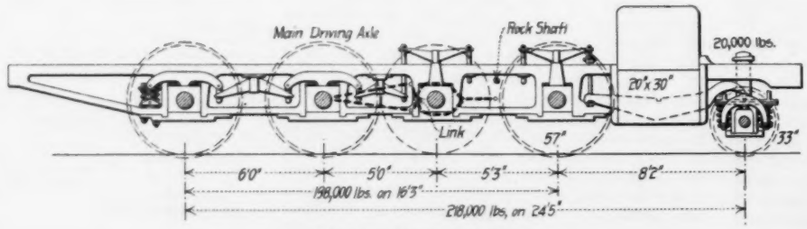
The proposed site for the filter beds is on land valued at 50 cts. per sq. ft., requiring an expenditure of $556,000 for land purchase, alone. Then the lay of the land is such that 731,000 cu. yds. of grading, at 30 cts., are required, making $219,000 more. Still further, the estimates provide for covered filter beds, notwithstanding the fact that Washington is in a comparatively mild climate, and that both Messrs. Weston and Hardy believe covering is unnecessary. The cost of covering the beds is estimated at $482,000. The report contains no reason for choosing so valuable land for the site of the filter beds, except the statement that the beds should be as near as possible to the new reservoir. The relatively small area required for the mechanical filter plant renders it of less importance that it should be built on cheap land, but with an item of $775,000 for land and preparatory grading in the case of the filter beds, or nearly $13,000 per 1,000,000 gallons normal capacity, it would seem worth while to make some estimates on other sites, especially as the water has to be pumped in any case. If the cost of land and grading were cut in half, and the filter [illegible]ft uncovered, a saving of $870,000, or over [illegible]-third of the whole cost, would be effected. This [illegible]ght be partially offset by the possible necessi[illegible] of providing a larger reserve filtering area a[illegible]an increase in the cost of scraping and carri[illegible]for the beds, besides which there might be an[illegible]m for conduit construction, but a large net g[illegible] might still be expected.

The report indicates that slow sand [illegible]ration would be insufficient during times of gre[illegible]t turbidity, but with the 300,000,000 gallon[illegible]torage capacity soon to be added, making ten d[illegible] storage in all, could not the river water be sh[illegible]off entirely during some of its most turbid peri[illegible]? This is given no consideration whatever in the report, but Mr. Weston does advocate supplementary coagulation, to relieve the slow sand filters at times of very turbid water. Colonel Miller [illegible]ntions this recommendation, but dismisses it by stating that no funds were available for investigating the plan, and that "no practical experience" with this system "is available." This latter statement is qualified on the preceding page by saying that the "system has never been operated in practice on a large scale." While the statement as qualified is probably very true, yet subsidence has been supplemented by coagulation with good results in several instances, notably at Kansas City, Mo., as described in Engineering News of Jan. 4, 1900. The combined capacity of the four settling basins at Kansas City is 60,000,000 gallons. The present average daily water consumption cannot be given, but it was 11,000,000 gallons a few years ago.

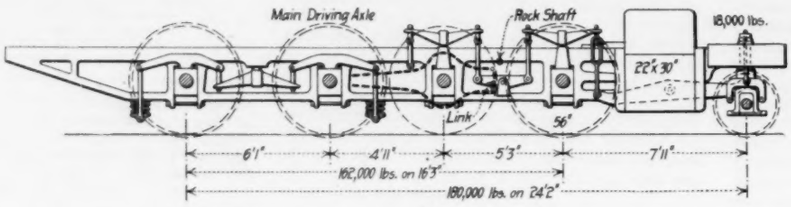
We have long wondered why some coagulant is not oftener used in settling reservoirs when the water is very bad. It requires almost no additional expense for construction, and the period of desirable use, in many cases, is so small that if the total cost were distributed over the whole year the increase per 1,000,000 gallons would be very small. A merely nominal expenditure at Washington would suffice to test subsidence and coagulation at the experimental plant.

While the effect of coagulation on the subsided water was being tried for a few months, there would be ample time to make new estimates for a slow sand filtration plant on a less expensive site, with beds not covered, and with a supplementary coagulating plant. At the same time, attention might be given to the possibility of excluding river water from the reservoirs during periods of maximum turbidity, and in addition the whole subject might well be referred to some engineer experienced in water purification. Unless Congress moves faster than usual in making appropriations for the benefit of the District of Columbia, there will be ample time to do all this before funds to start work are available, but even if further investigations resulted in delay they would still be warranted.

Two important questions relating to signaling and interlocking were discussed at the meeting of the Railway Signaling Club held in Chicago last week. The first of these was in regard to the source of supply from which railways are to obtain men for the signal department. At the present time, the repairmen form practically the only source of supply for inspectors and assistants, but these men are generally uneducated, and are not competent to deal with the general principles and practical problems which have to be met in the higher positions. The discussion was brought about by a paper presented by Prof. R. A. Smart, of Purdue University, outlining a suggested course of instruction in signaling and interlocking work. This would be based upon general courses of instruction in mechanical and electrical engineering, and might be taken in connection with the special course in railway mechanical engineering. Graduates from this course would have had some shop experience, and would be well grounded in mechanical and electrical engineering, and would have had the benefit besides of the special instruction in track work and in railway operation. These young men, beginning as repairmen, would be fitted by their education for promotion to higher positions from time to time. The development of the signaling department on railways in this country has been very rapid within the past few years,



Illinois Central R.R.



Cleveland, Cincinnati, Chicago & St. Louis Ry.

FIG. 2.—SPRING RIGGING OF BOTH LOCOMOTIVES.

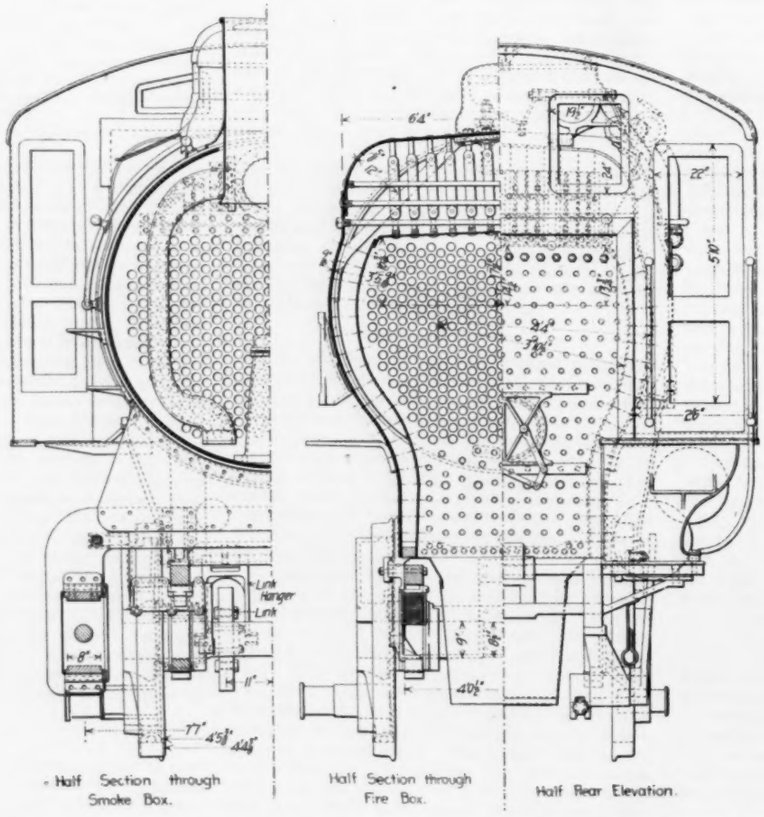


FIG. 5.—CROSS-SECTIONS OF ILL. CENTRAL ENGINE.

FIG. 1.—CONSOLIDATIO

Wm. Renshaw, Superintendent

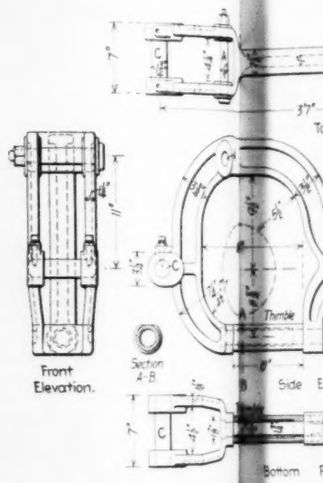


FIG. 4.—CAST-STEEL YOKE OF

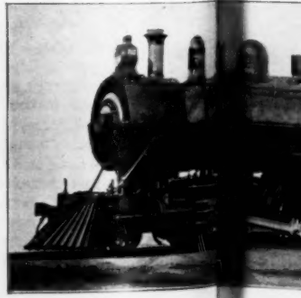


FIG. 6.—CONSOLIDATION LOCOMOTIVE:

LOU

Wm. Garstang, Superinte

Richmond Locomot

TWO HEAVY CONSOLIDATION LOCOMOTIVES

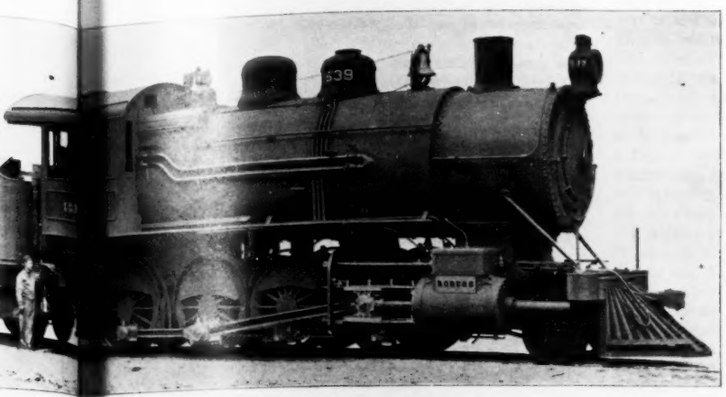
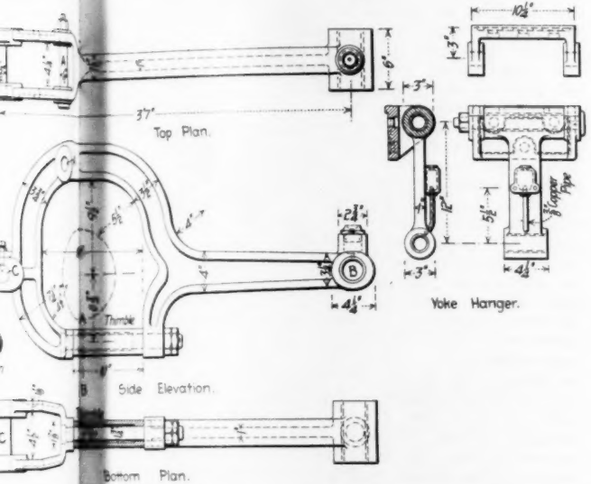
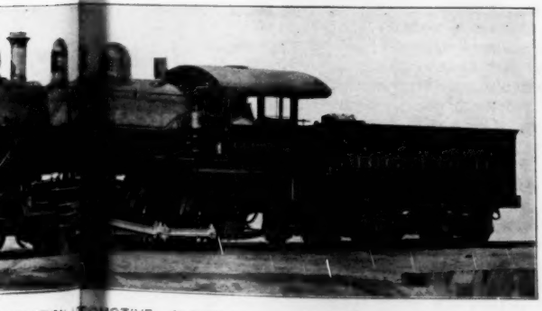


FIG. 1.—CONSOLIDATION LOCOMOTIVE; ILLINOIS CENTRAL R. R.
Wm. Renshaw, Superintendent of Machinery; Rogers Locomotive Co., Builders.



.—CAST-STEEL YOKE OF VALVE GEAR; ILL. CENTRAL ENGINE.



OLIDATION LOCOMOTIVE; CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.

Wm. Garstang, Superintendent of Motive Power.
Richmond Locomotive Works, Builders.

ATION LOCOMOTIVES FOR WESTERN RAILWAYS.

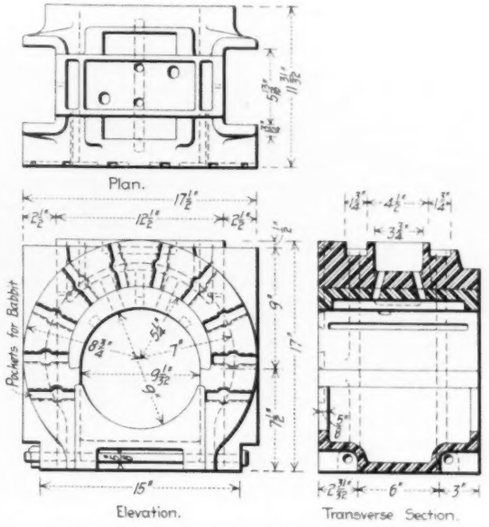


FIG. 3.—CAST-STEEL DRIVING BOX;
ILL. CENTRAL ENGINE.

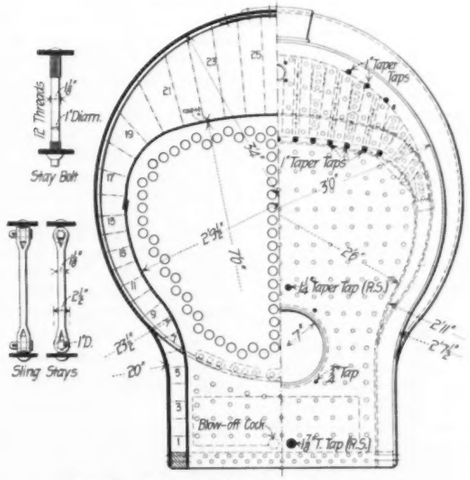


FIG. 8.—CROSS-SECTIONS OF BOILER.
C., C., C. & ST. L. ENGINE.

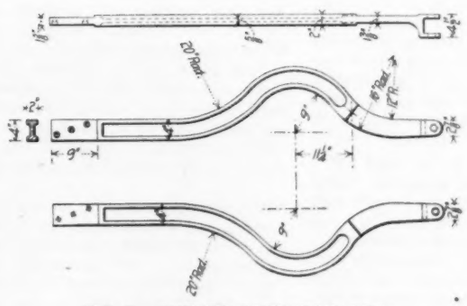


FIG. 7.—CURVED ECCENTRIC ROD;
C., C., C. & ST. L. ENGINE.

...been very unsystematic, as might be expected under the conditions. With the wide introduction and rapid extension of the equipment with which this department has to deal, its importance and its requirements will be more generally recognized, and there will undoubtedly be a growing demand for recruits of a somewhat higher grade and with more technical education than the men now commonly employed as repairmen and helpers. A start in this direction has already been made at some of the engineering schools, and is likely to develop a somewhat new field for the activities of engineering students.

Another subject discussed was in regard to the location of railway grade crossings, particularly at crossings where stations are located, and where cross-overs make connections. A paper by Mr. J. I. Vermilya, Supervisor of Interlocking of the Eastern District of the New York, New Haven & Hartford R. R. Co., was presented, and commenced by outlining the difficulties of operating at such a crossing, when protected by the usual arrangement of signals and derails. With trains making close connections, one train would have to pull up to the station and discharge passengers and baggage, and then back up out of the limits of the interlocking in order to enable the signals to be cleared and derails closed to allow the other train to come up. Then when the second train has gone, the first must return and make another station stop to pick up the passengers and baggage. The paper outlined a suggested plan involving the use of detector bars and extra signals by which it was claimed much greater convenience in operating would be secured, while an engineman running past a home signal at "stop" would have sufficient space in which to stop before reaching the second home signal. In the discussion of this paper, by the members of the Signaling Club, the proposal to do away with derails met with unanimous disapproval, and it was shown that a man who would run by two signals would be just as likely to run by the third signal. Various instances were cited to prove the absolute necessity of derails, but on the other hand it was stated that crossings on Eastern railways had been very generally worked without derails until within recent years. The general sentiment, however, was that the absolute derailing of a train should be provided for as a means of safety at all crossings. On the Illinois Central R. R., at locations similar to that described by the author, two derails are put in. A train making a station stop passes the main (or high speed) derail, but is held by a second derail between the station and the crossing. With the train standing at the station and the crossing thus protected, the signals can be cleared for the other line. In this connection it may be noted that the Western Society of Engineers recently devoted an evening to the discussion of a patented system of protecting grade crossings by devices which would automatically set the brakes on a train passing a home signal at danger. As few of those present were familiar with signaling or with train service, the discussion fell rather flat. The same device was referred to in the discussion by the Railway Signaling Club, but such a system was considered unsafe and not consistent with good practice.

The mine disaster at Scofield, Utah, which was briefly noted in our last issue, turns out to have been a dust explosion. Whether the dust was originally fired by the explosion of a small quantity of powder or a jet of mine gas will probably never be known; but in either case the primary cause of the disaster was the dust which was heavily scattered all along the workings, ready to be taken up and disseminated in the air to carry the flame onward by the rush of air following any slight explosion. The deaths which occurred, however, were not all due to the explosion, but largely to the volume of noxious gases (carbonic oxide chiefly) which it generated, and which gradually permeated the entire mine. The force of the explosion demolished the interior ventilating system, as usually happens in a mine explosion, and there was no means of withdrawing the foul gas from the mine before its deadly work was done.

This fatal disaster, with its long death roll, adds another to the list of serious casualties that have been caused by the explosion of dust. Every engineer should write it down—not in his note book, where it may be overlooked, but in a prominent place in his memory—that any combustible dust is, under proper conditions, a dangerous explosive, and should be guarded against as if it were dynamite or gun cotton.

It is not often realized how small a quantity of dust is required, floating in air, to form an explosive mixture. If perfect combustion were attained, about 12 lbs. of air would be required to burn one pound of carbon. Practically, however, a far larger quantity of air than this is required, and 25 to 50 lbs. are probably frequently drawn through a fire to burn 1 lb. of coal, and a dust explosion might take place, it is probable, when air and dust are mingled in the proportion of 50 to 100 lbs. of air, or even more, to one pound of dust. Taking the weight of air as 1-13-lb. per cu. ft., a room 10 ft. square and 10 ft. high would contain about 77 lbs. of air, hence the dissipation of a single pound of dust through such a room might be sufficient to create an explosive mixture.

On the practical side, it is well known that flour mills, candy factories and other dust-creating works have been blown up when the quantity of dust about them was by no means unusually large. Dust is bad for operatives, bad for machinery, and dangerous into the bargain. Numerous methods for its suppression are now available, and there is no good excuse for its presence in dangerous amount in any manufactory.

The recently issued annual report of the General Electric Co. is a notable document, both as an example of conservative accounting and administration in the financial affairs of a great corporation, and because of its frank public statement of facts and figures which most corporations keep secret. We are told, for example, that the total sales of the company last year were over $22,379,000; the expenses, including taxes and depreciation, were in round numbers, $18,573,000, leaving a profit on goods sold of over $3,800,000. Of this profit, $1,282,000 is paid out in dividends and interest, and the rest is apparently put by for a rainy day. Manifestly, such a huge business as 1899 rolled up cannot be expected to be permanent. It is of interest in this connection to note that the total factory floor space in all the company's works is in round numbers, 2,000,000 sq. ft. Thus the company made a profit in its manufacturing operations in 1899 of nearly two dollars for each square foot of floor space in its factories.

THE SAN FRANCISCO GARBAGE DISPOSAL WORKS AND FRANCHISE.

The San Francisco garbage crematory, described elsewhere in this issue, is the largest single plant for burning garbage yet built in this country, if not in the world. It has a rated capacity of 600 short tons a day. It is also notable for requiring no fuel save the wastes it is designed to burn, a rare thing in this country, although common enough in works abroad.*

Unfortunately, no complete figures of cost of operation could be obtained by Mr. Mills, the engineer who investigated the San Francisco plant for us and prepared the article in question. This is largely due, we suppose, to the fact that the plant is owned and operated by a private company, under the unique conditions described below.

The company reported its labor account during March, 1900, as at the rate of $40 a day, from which and other figures Mr. Mills computes the cost of garbage cremation, for labor alone, at 6 cts. per cu. yd., or 15 cts. per short ton, not including the disposal of ashes and clinker. The company states that the latter item is a trifle more than offset by the revenue from the sale of the material for filling in low grounds near the works, but that does not help any one who desires to learn the actual operating expenses of the furnaces. The company reports very light expenses for repairs during the 2½ years it has been in operation, but these will doubtless be heavier in the future. It carries no insurance. As it does not use its steam plant, its expenses for water are presumably light. No information as to taxes is given. There have been heavy legal expenses, but chargeable against the company's exclusive franchise for garbage disposal, rather than to the method of disposal itself. The first cost of the plant is given by the company as $75,000. The amount of garbage reported as burned since the works were started was 232,920 cu. yds. from Nov. 8, 1897, to Dec. 31, 1898, and 169,201 cu. yds. for the year 1898, a total of 402,121 cu. yds., estimated at 160,848 short tons. The total period covered was 784 days, or 672 working days. This gives 205 tons for each day in the year, or 240 tons for each working day. The figures for the year 1899 alone are only 216 tons per working day, due, it is said, to the fact that the scavengers failed to deliver large quantities of refuse to the crematory the first part of the year, as explained by Mr. Mills in his article. The labor account of $40 a day for March, 1900, was said to correspond to a daily treatment of 260 tons. What the actual average labor account has been for the period since the plant was put in operation, or what it was for the year 1899, we cannot say. Assuming labor at $40 a day through the whole of 1899, the cost of labor per ton, for an average of 216 tons per working day, is a little less than 19 cts. It should be noted, however, that the men work eleven hours a day, which is three hours longer than would be permitted on municipal work in some Eastern cities, or, we believe, than is now allowed on new municipal contract work in San Francisco. It may be added, before leaving the question of cost of labor, that on Feb. 4, 1898, about three months after the plant was put in operation, Mr. Chas. J. Okell, Secretary and Treasurer of the Thackeray Incinerating Co., of San Francisco, wrote us that its furnaces were "now incinerating the garbage of San Francisco without the aid of fuel at a cost of 14.9 cts. per ton." It will be seen, from the foregoing, that the parties in interest are united and persistent in claiming 15 cts. per ton as the cost of labor at the San Francisco crematory. The claims would rest on a better foundation if they were based on the actual labor account and quantity of refuse burned for a year, instead of figures for a day or month, assumed to be representative of a larger period. Besides this, it should not be forgotten that no allowance is made for the final disposal of ashes and clinker.

As to there being no fuel bill at these furnaces, it must be remembered that the matter consumed is mixed refuse, containing quite a proportion of readily combustible matter, the contract or franchise virtually requiring all wastes passing through the public streets to be taken to the furnace. This, it is reported, has been interpreted by the company to include combustible wastes which manufacturing concerns stand ready to use under their boilers, but how much truth there is in the report we cannot say. It is interesting to note in passing that the assumed weight of all the material burned during the 26 months ending with the close of 1899 averages 410,000 lbs. for each day in the year (on the assumed basis of weight), or 1.14 lbs. of mixed refuse per capita, the population being taken as 360,000 on Jan., 1899, which is the estimate reported by the health authorities of San Francisco.

We have given all the available figures on which estimates of cost of garbage cremation at San Francisco may be based and have reduced some of them to more convenient form for comparison with other cities. It will be seen from this presentation that when allowance has been made for removing ashes and clinker, repairs, water, taxes, sundry supplies, salaries of the officials of the company and, last but not least, capital charges, the cost for handling material will be quite different from 15 cts. per ton for labor alone, which latter figure may or may not need appreciable change to arrive at the actual average cost of labor during a year or more. But even with all these corrections, a figure would not be reached on which it would be safe to base an estimate of the cost of refuse cremation in a Thackeray furnace, with material like that at San Francisco, for there still remain legal ex-

*For description and comments on a similar but smaller plant at Montreal, see Eng. News, Nov. 29, 1894; Dec. 7, 1899, and Feb. 22, 1900.

penses to be met. Although these expenses have doubtless been higher at San Francisco than would be the case in most other cities, owing to the fact that the owners of the plant have had an unusual struggle on account of attempting to maintain the exclusiveness of a franchise for garbage disposal, yet legal expenses have arisen over nearly every garbage disposal plant erected and operated by private contractors, regardless of whether cremation or reduction was employed. We are not referring to the ordinary legal expenses of drawing contracts and the like, but of those due to what may be termed a struggle for the right to build and operate such works. At San Francisco, as in some other instances, these extraordinary expenses have doubtless been so great and of such a character that they might be more properly charged to capital than to operating expenses, but they must be met and increase of total cost of garbage disposal, wherever it is carried on.

In bringing up all these points we are not seeking to belittle the efficiency of the San Francisco plant, but merely to caution our readers against being misled by the statement that garbage is being treated there at a cost of 15 cts. a ton. Except for the indefinite basis on which that figure rests, however, it is a perfectly legitimate one for comparative purposes, so long as contrasts are not drawn between it and others composed of different items. We do not doubt but that the total cost per ton is very low, after making all allowances. In fact, the plant must be run at a very low figure or the company would go into bankruptcy, since its only visible sources of revenue are 20 cts. per cu. yd. (assumed at 50 cts. per ton) charged to the scavengers for all material delivered by them; whatever salable material can be obtained by sorting the refuse; and the value of the ashes and clinkers. The company reports that practically all salable material is reclaimed by the scavengers before they bring the wastes in and that the sale of ashes and clinkers only a little more than covers the cost of removal. If the 402,000 cu. yds. of refuse reported as consumed during the 26 months ending with Dec. 31, 1899, was the basis of charges to scavengers at 20 cts. per yd., then the total revenue from that source for the period named was about $80,000, or about $37,300 a year.

Reference has been made to a franchise under which the owners of the crematory are working. We believe the conditions at San Francisco, as set forth in detail by Mr. Mills, are unique in this respect. The municipal treasury profits directly from the system in vogue, instead of being called upon to pay out money for the removal and final disposition of garbage, ashes, tin cans and other miscellaneous wastes. But it is doubtful whether this is not a case of saving at the spigot and wasting at the bunghole, when the health and other broader interests of the city are considered. Our readers can judge for themselves on learning more of the facts in the case.

So far as we can learn, San Francisco never has had a public system of refuse collection, leaving the matter entirely to private scavengers and householders, for such mutual arrangements as they might effect. The health authorities did the best they could, until the garbage furnaces were built, to prevent nuisances from garbage dumps. About 1894, or earlier, steps were taken by the city to build a crematory, but the Board of Supervisors seem to have let the matter go by default. Later on the supervisors determined to make arrangements for final disposition, only, leaving the private scavengers to meet the expense. In other words, they proceeded to advertise for bids for a garbage disposal franchise, the State Constitution requiring that all franchises must be sold to the highest bidder. After receiving various bids for a 35-year franchise, and rejecting them on the technical ground that the advertisement did not stipulate the charge to scavengers for final disposition, a new call was made. This was for a 50-year franchise, the successful bidder being limited, virtually, to a charge of 20 cts. per cu. yd. for all material brought to the works. The award was made on the basis of a payment to the city of a lump sum of $2,510, with additional yearly payments of 2 per cent of the gross receipts for the first 15 years and 5 per cent. for the last 35 years of the franchise. The franchise was designed to be absolutely exclusive; that is, all garbage and other wastes, except night soil, collected and hauled through the public streets must be taken to the disposal works erected under this franchise and on their delivery 20 cts. per cu. yd. must be paid for their disposal.

This monopoly feature of the franchise, together with its long term of 50 years, has excited much bitterness, which has been shown chiefly by the scavengers. After numerous cases of individual arrests and fines for dumping wastes in vacant lots, instead of taking them to the furnaces, a Scavengers' Union was organized and counsel retained to carry on the war. This Union, as well as disappointed bidders for the franchise, has made various attempts to prove the franchise, or its exclusive features, invalid, but thus far all these attempts have failed. Quite recently, the struggle broke out anew, and some scavengers were fined $100 each for dumping wastes on vacant land, the court increasing the fines tenfold in the hopes of bringing the fight to an end.

Naturally, the change from free dumping in vacant spaces to hauling to a crematory and paying 20 cts. a cu. yd. forced the scavengers to increase their prices to householders and others. The advance was reported in the local papers as 20 per cent., raising the minimum price to small houses from 25 to 35 cts. a month for removing their wastes. This naturally discourages the people of the crowded sections of the city, who stand most in need of thorough-going service, from having their wastes properly removed. Mr. Mills informs us that fear of arrests for maintaining nuisances doubtless does much to ameliorate the conditions that might be expected from having so large a city wholly dependent on a private scavenger system of garbage collection.

The city has taken definite steps, once or twice, to provide for refuse collection and disposal at public expense, but the plans outlined have been met with the protest that they were designed to enrich the owners of the garbage furnaces, and the propositions have been abandoned.

While it appears that San Francisco has one of the finest garbage disposal works in the world, it is by no means clear that the franchise under which it is operated is for the best interests of the city, or that the private scavenger service is all that the health and other interests of the city demand. The term of the franchise, under almost any conditions, is far too long, and it is questionable whether sanitary works, especially, should ever be carried on under franchises. There are two features favorable to the city: (1) It is assured of a percentage of the gross receipts; and if it sees fit at any time to install a public system of waste collection it is assured that it need pay but 20 cts. per cu. yd. for final disposition, on delivery to the furnaces. Such assurance is comforting, at first thought, but whether or not a virtual 50-year contract for disposing of mixed refuse at that price is really a good one for San Francisco we shall not attempt to say, with the data in hand. Much of the refuse, if unmixed with garbage, could be got rid of for nothing, as witness the statement in Mr. Mill's article that the cost of hauling clinkers and ashes from the furnaces is a little more than met by the payments for the material for filling purposes. Then, too, if the dreams of some of the enthusiastic believers in the reduction system ever come true, garbage disposal ought to cost a city nothing, to say the least, while on the other hand the equally enthusiastic advocates of cremation would have us believe that enough heat from garbage furnaces may be utilized more than to pay the expenses of cremation.

That this latter hope is based on very poor foundation, so far as American conditions are concerned, has been already pointed out in these columns. Those who have prophesied that garbage disposal works could furnish light, heat and power to the cities in which they are located will be interested to note that no use is made of the heat escaping from the San Francisco furnaces, notwithstanding the fact that they are located in a city where coal is as expensive as it is anywhere in the United States.

LETTERS TO THE EDITO

The Preservation of Railway Ties by the ilmany Process.

Sir: In answer to inquiries called out by my r pub- lished in Engineering News Aug. 17, 1899, I m y that I have not treated any ties by the zinc and bari process since 1880. They were placed on the New Eng l R. R. or the New York & Hartford R. R. Major You ad the disposition of them. Having left New York in 1 I have lost track of their record. The last I heard w hrough Major Young, that after six years' service they re still in good condition. These ties were treated in ylinder built for the treatment of wood in general. Th ere of North Carolina tapped pine and spruce and Virg spruce pine. I believe they cost 35 cts. each, and the atment cost 15 cts., making a total cost of 50 cts. per t

In 1874 there were four ties treated with the r and barium process for the Cleveland & Pittsburg R. There was one tie each of red beech, whitewood or p r, soft maple and black oak, the oak being treated by h ostatic pressure. After being 4½ years in use they were removed from the track. Two years later the beech tie was discovered in a side track in perfectly sound condition, and it was almost impossible to draw the spikes witho breaking them. This would make a life of 6½ years, which is a long life for beech ties. E. Martin.

18 Chestnut St., Cleveland, O.

The Elgin Stand-Pipe Failure.

Sir: The articles on the failure of the stand-pipe at Elgin, Ill., in your issue of May 3 are very interesting. It has occurred to me that possibly the real cause of the failure was due to the plates of the pipe being called upon to act as a column in supporting the body of ice which the drawing down of the water left suspended in the top of the pipe. Add to this the weight of the pipe itself above the point of fracture, together with the ornamental work on top and any wind vertical component there may have been at the time, and the lower plates, it would seem to me, could be compared to the web of a circular girder with a pressure on one side tending to make the load eccentric. While the pipe is full the ice has a tendency to float, or, more clearly, is water-bourn. As soon as the water begins to drop all ice not water-bourn and frozen to the plates must be supported by the plates, and the very fact of a part being melted away from the plates on one side may (or may not) have caused the northeast side of the pipe to bear not only its share of the load, but as much as may have been supported by the tensional strength of the ice.

I, for one, should like very much to have Professor Pence discuss the failure from this point of view with his knowledge of the facts; and, further, if this conclusion is correct, for the mutual benefit of the profession engaged in the construction of works of this class and those using stand-pipes similarly exposed. Would it not be well to discuss the question of adding sufficient stiffeners to the plates of these stand-pipes to carry such extra load as is reasonable to expect may be thus brought upon them by this exposure, the same or in a similar manner to the stiffeners of a plate girder web?

For the purpose of illustration, I will assume, roughly, as follows: Fourth ring, 30 ft. diameter, 1,131 ins. circumference; thickness by Professor Pence, 19-32 in.; area of section, 672 sq. ins.; weight of pipe per lin. in. of circumference plates, laps, rivets, etc., above and including fourth ring, but without ornamental work, about 80 lbs., or a compressive weight of 150 lbs. per sq. in. Of the 800,000 lbs. of ice in pipe 23 ft. of 30-in. ice and the 70,000-lb. cake, or 361,622 lbs., were supported by the ring as a column. This is equal to 538 lbs. per sq. in. of section. By unequal freezing this may be doubled or trebled, making a load of not less than 538 + 150 = 680 lbs., or 1,076 + 150 = 1,226, or 1,614 + 150 = 1,764 lbs. per sq. in. as a column, possibly more, in addition to the hydrostatic pressure on one side of the web of this column. The plate would then give way by crippling first, and then the usual course would follow. It seems to me this was the cause of the accident, and the appearance of the several views would seem to confirm it. It may have been that the metal had been strained before beyond its elastic limit under similar conditions, and this was "the last straw."

Allow me to congratulate you upon the very satisfactory way in which you are presenting these matters, including the Austin dam. It is by failures that we learn; the successes take care of themselves.

Very respectfully yours,

Saint John, N. B., Nov. 9, 1900. F. W. Holt.

Some Matters Relating to Engineering Ethics.

Sir: Everyone has the right to the protection of his property against theft, and there are ample laws for the punishment of those who trespass upon this right. There are, however, certain classes of rights which laws cannot defend, and which, when violated, constitute even greater crimes than the theft of money or goods, if viewed with impartial judgment. There are those who, through fortunate circumstances and influential connections, have received appointments to engineering positions of trust and

responsibility, but who are actually diplomatists rather than engineers. These rely upon their subordinates for the solution of all professional problems. Such a diplomatist and quasi-engineer may claim a distinguished alma mater and have had ample training for an engineer's work, yet nature has not endowed him with capacity for the work of an engineer. In many cases such a man will have good judgment in the selection of subordinates and will rely implicitly upon their judgment and ability. Yet when the work is brought to a successful completion he will not hesitate to take to himself the credit for the design as well as the successful construction. The man who will take credit to himself for the original ideas and work of a subordinate should be placed in the same category with a thief. In fact, he is worse than a thief, for the latter appropriates property which it is possible to replace. Such treatment discourages and often blights the prospects of young engineers. The grammar school episode in Holmes' "Martin Chuzzlewit" is very often duplicated in present day life. It is seldom, however, that the Peck-sniffian engineer receives such wholesome and well-deserved punishment as was administered by the elder Chuzzlewit.

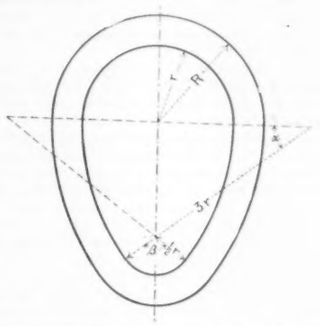
There should be an unwritten law in the profession which would militate against all such persons and their methods. Such persons should be ostracized by all engineering societies. No man is an engineer until he has proved himself worthy of the title by designs and the successful execution of work traceable directly to himself. Too many men owe everything to subordinates whom they keep in discretionary silence by what might be called coercion. The field of engineering is large enough for the broad-gage engineer with real capacity and ability to give credit wherever it is due. Numa Pompilius.

Philadelphia, Pa., May 12, 1900.

(We may remark, for our correspondent's comfort, that nothing has happened to him which is not common to the lot of man. Very few engineers —or men in any calling—go through the period of active life without doing more or less work for which others receive such credit as is allotted. After all, is the case quite so bad as our correspondent puts it? We will agree, of course, that credit should be given where credit is due, and nowhere else; but what an evanescent and will-o'-the-wisp affair credit is after all. How fickle a goddess is fame, has been well shown by recent public events. Is it always the greatest soldiers or statesmen or scholars or artists or engineers, whom the public chooses to immortalize? The desire to receive suitable recognition for good work, well done, is an honorable ambition; but it is the part of wisdom to preserve a philosophical spirit when the busy world doesn't stop to look or carelessly gives the praise to the undeserving. And after all, is not the approval of one's own conscience and the recognition of nearest friends a better reward than the undiscriminating applause of the multitude?—Ed.)

Formulas and Diagrams for Computiug Quantities of Brickwork in Egg-Shaped Sewers.

Sir: In your issue of April 19, 1900, I note certain formulas for determining the quantity of brickwork in egg-shaped sewers. In the hope that if may be found useful, I append the following solution of the same problem made several years ago:



Let A = area limited by exterior of brickwork.
a = area of interior of sewer.
A — a = area of brickwork.
R = radius of outer arch.
r = radius of inner arch.
3 r = side radius (inside).
½ r = radius of invert (inside).

Ratio of horizontal to vertical diameters, 2 : 3. Angles δ and β are constant,

$$\begin{cases} \delta = 36^\circ\ 52'\ 12'' = 36.87. \\ \beta = 106^\circ\ 15'\ 36'' = 106.26. \end{cases}$$

Then

$$a = \frac{\pi\ r^2}{2} + 2\left\{\frac{36.87}{360}\ \pi\ (3\ r)^2 - \tfrac{1}{2}\ 2\ r\ \frac{3}{2}\ r\right\} + \frac{106.26}{360}\ \pi\left\{\frac{r}{2}\right\}^2.$$

$$= 1.5708\ r^2 + 2.7916\ r^2 + 0.2318\ r^2.$$
$$= 4.5940\ r^2.$$

It follows directly then that the area of the brickwork is

$$A - a = 4.5940\ (R^2 - r^2),$$

or, dividing by 27 we have for the volume of the brickwork $0.17\ (R^2 - r^2)$ = cubic yards per lineal foot of sewer.

Very respectfully, S. M. Swaab,
Assoc. M. Am. Soc. C. E.

Bureau of Surveys, Philadelphia, Pa., April 24, 1900.

Sir: I notice in your issue of April 19, quite a discussion on estimating the quantities of brick in brick sewers. I enclose a couple of diagrams which I have used for this purpose for several years, and which seem to be much more convenient than the formulas proposed in your issue.

Very truly yours, Geo. S. Pierson,
M. Am. Soc. C. E.

Kalamazoo, Mich., April 23, 1900.

Sir: The "Formulas for Computing Quantities of Brickwork in Egg-shaped Sewers," prepared by Philip P. Farley, published in Engineering News of April 19, 1900, calls to mind a "rule of thumb" that will be found both convenient and accurate in estimating the number of brick required for each lineal foot of egg-shaped sewer. Rule: Add the two diameters expressed in inches for a single 4-in. ring. For a double ring, or 8-in. shell, double the sum of the diameters expressed in inches and add 16.

This rule will also be found convenient for making up approximate estimates for circular brick sewers and manholes. For example, a 5-ft. circular sewer with 8-in. shell, or two rings, requires $N = 2\ (60 + 60) + 16 = 256$. Folwell's "Sewerage," table 23, gives 262 as the required number, a discrepancy of about 2%. For manholes, add the diameters, both top and bottom and 16, for each foot in depth. Example: Manhole 36 x 54 ins. in plan, tapered to a circle 28 ins. inside diameter, 10 ft. deep, $N = 36 + 54 + 28 + 28 + 16 = 162$ per ft., or 1,620 in all. This does not include foundation. Respectfully,

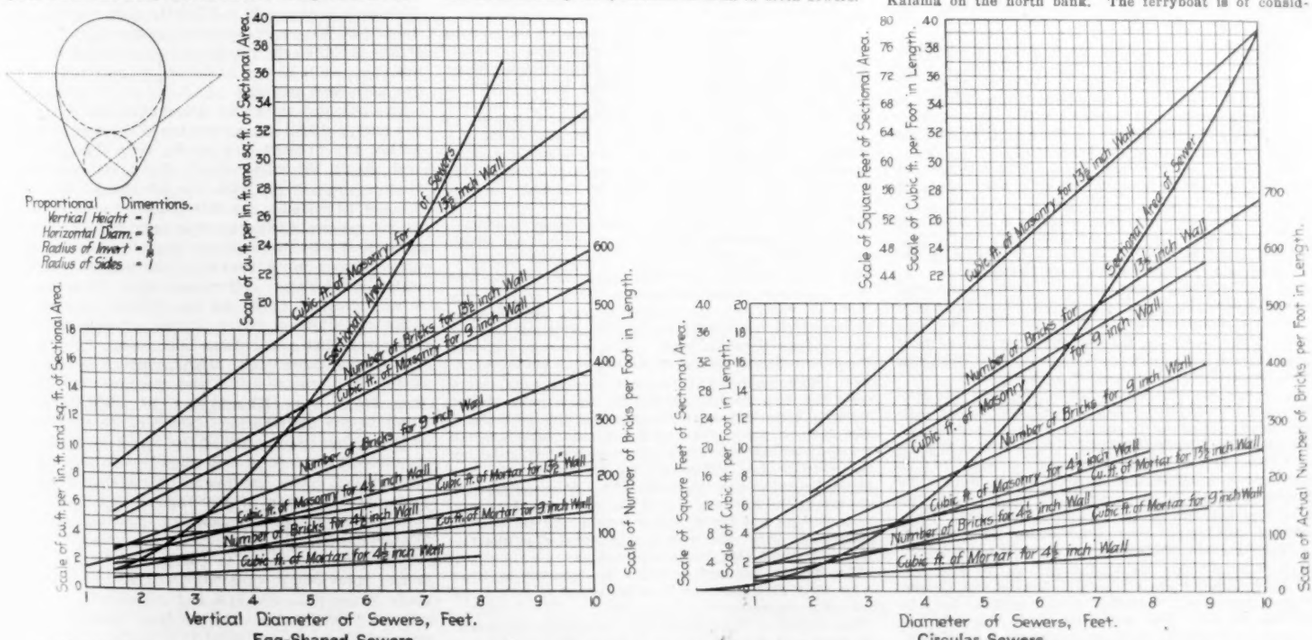
W. J. Roberts,
Assoc. Prof. Dept. Civil Engineering.
Washington Agricultural College and School of Science, Pullman, Wash., April 23, 1900.

Portland, Tacoma and Seattle, as Seen by An Engineer.

Sir: The Portland Union Station is one of the most pretentious on the Pacific coast. It is built of brick, with stucco work for exterior finish. The streets of the city are well provided with electric street car lines, but the pavements are quite poor. The business blocks, although not large, are many of them of quite solid construction and the business sections impress one favorably.

The river steamboats appear to be for the most part small stern-wheel craft with single stacks and do not compare with the steamers on Eastern rivers. The coastwise steamers of the Oregon Ry. & Navigation Co. run from Portland to San Francisco in 50 hours, a distance of 765 miles. The "Columbia" of this line is 334 feet long and of about 3,000 tons capacity. The vessels of the Northern Pacific Steamship Co. run from Portland to Oriental countries, and there is more or less shipping from Portland for Alaska The "Columbia" river jetties have not been the success that was hoped in maintaining the depth across the bar at the mouth of the river and continual dredging is necessary to maintain the necessary depth for large vessels. The ships of the American-Hawaiian Steamship Co. are expected to be in commission by July, and are to run from Portland and other Pacific coast points, Honolulu and New York. They will be about 430 feet long and 51 feet beam and will have a carrying capacity of 15,000 tons.

The Northern Pacific Ry. line from Portland to the north follows down the two rivers until Goble is reached, where a ferry transfers the train across to Kalama on the north bank. The ferryboat is of considerable length, with three tracks. The ends are sloped down towards the water and sheathed with plate iron, so that the aprons at the slips are wedged up to track level as the boat lands. The aprons are raised and lowered to approximate level by large lever tackles, instead of the ordinary screw or windlass.


Proportional Dimentions.
Vertical Height = 1
Horizontal Diam. = 2/3
Radius of Invert = 1/2
Radius of Sides = 1
Scale of cu. ft. per lin. ft. and sq. ft. of Sectional Area.
Scale of Number of Bricks per Foot in Length.
Cubic ft. of Masonry for 13½ inch Wall
Sectional Area of Sewers
Number of Bricks for 13½ inch Wall
Cubic ft. of Masonry for 9 inch Wall
Number of Bricks for 9 inch Wall
Cubic ft. of Masonry for 4½ inch Wall
Cubic ft. of Mortar for 13½ inch Wall
Number of Bricks for 4½ inch Wall
Cubic ft. of Mortar for 9 inch Wall
Cubic ft. of Mortar for 4½ inch Wall
Vertical Diameter of Sewers, Feet.
Egg-Shaped Sewers.
Scale of Square Feet of Sectional Area.
Scale of Cubic ft. per Foot in Length.
Scale of Actual Number of Bricks per Foot in Length.
Diameter of Sewers, Feet.
Circular Sewers.

DIAGRAMS FOR DETERMINING AREAS OF CROSS-SECTIONS, CUBIC FEET OF MASONRY AND MORTAR AND NUMBERS OF BRICK PER LINEAL FOOT FOR EGG-SHAPED AND CIRCULAR SEWERS.

By Geo. S. Pierson, M. Am. Soc. C. E.

(Bricks taken as 4 x 8¼ x 2¼ ins., with ½-in. interior joints.)

The works of the Western Iron & Steel Co., at Lakeview, consist of a small rolling mill, which, judging from the piles of scrap iron about, uses but little new stock, but is intended to utilize old material. South Tacoma is the location of the Pacific coast works of the Griffin Car Wheel Co., and the shops of the Northern Pacific Ry., both of which are extensive plants.

The station at Tacoma is an unpretentious wooden affair, and a better structure is needed. Tacoma streets are, as a rule, well graded, well paved in the business portions, and clean. The pavements, made with rectangular fir blocks set on a concrete base and with tarred joints, are in splendid surface and elegant for driving. The walls of the great Hotel Olympic are still standing as they were left by the fire which gutted the interior before the building was completed. The Hotel Tacoma is a large handsome structure farther down town, and commands a fine view of the Sound and of Mt. Rainier, or, as they call it here, "Mt. Tacoma."

Along the water front are numerous mills and shops. Across on the flats are the packing houses of the Pacific Meat Co., and the mills of the St. Paul & Tacoma Lumber Co. The extensive docks of the Northern Pacific Ry. are being extended, new warehouses being put up and other improvements under way to accommodate the increasing ocean traffic of the Oriental and Alaskan lines.

The distance from Tacoma to Seattle by rail is 41 miles, as trains run due east to Meeker before turning north. The distance by steamer up the Sound, a nearly direct line, is only 28 miles. The ride by train is very uninteresting, with but little for scenery except the stumps and burned trunks of trees in the worked-out timber lands. Seattle is entered over a trestle across mud flats, which are bared at ordinary low tide, the range of the tides here being over 13 feet. At the present time the city is waiting for the elegant new station which "is to be built" sometime by the several roads in conjunction, and passengers are landed on Railroad St., within a block or so of the business portion of the city and directly at the water front.

The Northern Pacific has extensive piers here, as has the Great Northern Ry., at Smith's Cove, a small bay at the upper end of the city, where are also extensive elevators and warehouses to accommodate the Japanese steamship line. Enlargements are being made for the great steamers which President Hill is having constructed for the Oriental trade. The Columbia & Puget Sound Ry., owned by the Pacific Coast Co., has lines to the coal mines at Renton, Franklin and New Castle. Extensive coal pockets are located adjacent to the wharves of the Pacific Coast Steamship Co., where the coal is loaded into vessels for shipment and transferred to the cars of other railways for shipment by land.

The Canadian Pacific Ry. also reaches Seattle over the Seattle & International Ry., running its own through cars to and from the East.

The coal fields of the Puget Sound country are more extensive than is generally appreciated in the East. The coal from Vancouver Island might be included under this head, as it is close by, being shipped from Nanimo on the eastern shore. The collieries there were originally owned by the Hudson Bay Co., and are shipping over one million tons per year at the present time.

The counties of Whatcom, Skagit, King, Pierce and Thurston in the state of Washington have mines in operation.

The coal fields of King county, from 20 to 30 miles from Seattle, produced last year about three-quarters of a million tons. One half of the amount was shipped to San Francisco and the balance was used locally.

The coal of Pierce county is sent to Tacoma for shipment, and the amount is said to exceed that shipped from Seattle. A considerable amount of this coal is of coking quality. The coal from Kittitas county is shipped from both Tacoma and Seattle. The total coal production from the state for 1899 exceeded 2,000,000 tons.

The timber has practically disappeared along the railways. But there is still plenty farther back. Recent estimates of the amount of timber west of the Cascade Mountains place the amount at 103 billion feet still standing, divided about as follows: Fir, 66 billion feet; cedar, 16 billion; hemlock, 14 billion, and spruce, 6 billion. East of the Cascades the amount is placed at 10 billion feet. The forest fires are said to have destroyed over 20% of the timber in Washington! About 23% has been cut and sawed, thus leaving about 57% as the amount still standing.

It is estimated that the total output of the mills last year reached nearly one billion feet. Lumber was shipped all over the world, including seven million feet to the Boer republic. The rail shipments to the East has increased very rapidly, reaching over 38,000 cars in 1899. The fine character of the timber is so well known as to require no description, further than to mention some recent sticks 112 feet in length, 51 inches in diameter, and weighing squared up 97,000 lbs.! The mills at Port Blakely are said to be the largest in the world.

The shingle industry is one of the most extensive branches of the lumber business here, the output of shingles for 1899 reaching 3,476,900,000 pieces.

The steamship lines necessary to handle the enormous lumber exports, and to carry on the trade with Alaska and the Orient make Puget Sound a busy expanse of water. Large numbers of small craft carry on the trade between the Sound cities and towns. The steamer "Flyer," of about 250 tons, makes four round trips daily between Tacoma and Seattle. A speed of 18 knots is maintained for the entire 28 miles, so that the run is made from city to city in 80 minutes. The hull was built in Portland and the triple-expansion engines in Philadelphia. The cabin is fitted up with reclining chairs, a double row down each side like a railway chair car, and the seats are well filled each trip.

The Pacific steamship lines are those of the Northern Pacific Co., the Japanese Steamship Co., and the new line of the Great Northern Ry. which will soon have its ships in commission.

The coast lines are quite numerous, the Pacific Coast Co. having its line to San Francisco and extensive service to Alaska. There are numerous other lines to Alaska, both to southern ports and to Cape Nome. So great has been the demand for accommodations that every vessel at all suitable has been pressed into service. The running time to Skagway has been reduced to 50 hours, and Alaska is actually nearer Seattle than San Francisco. Supplies of all kinds are being sent north by the shipload, including all styles and kinds of mining machinery, good, bad and indifferent. While other coast cities are sending many vessels to Alaska, Seattle retains the bulk of the trade. One soon comes to regard Alaska in a much different light than when considered from an Eastern point of view. The climate of Southern Alaska is so moderated by the Japan current that in Skagway the thermometer seldom goes below zero. From Skagway north the White Pass & Yukon Ry. runs to Bennett and will soon be completed to White Horse, 112 miles from the coast. Traffic over this road was kept up all through last winter, rotary snow-plows being used, the crews being from the Cascade Mountains, where the snow is much worse as a rule than over White Pass. The equipment is all of the best, many of the cars being constructed at the railway shops at Skagway! By this route Cape Nome is reached down the Yukon a month or so earlier than is possible by steamship. The rush to Nome will be greater than to the Klondike. It is quite certain that at least 30,000 people will go during the season, and the number will very likely approach 50,000.

Seattle is crowded with people either going to the gold fields or connected in some way with the outfitting of others. Available vacant lots and buildings are used to exhibit the "latest thing" in rockers, dredgers and various mining machines, and a very large number of outfits are being sold every day which will be of no service whatever in practical mining.

The business portions of the city have been built up with large handsome blocks since the great fire, and nowhere west of Chicago is there a city with a more metropolitan aspect.

The pavements of various streets are much in need of replacing. Much of the paving consists of plank, laid crosswise upon mud-sills, and after becoming badly worn it becomes a somewhat improved form of corduroy road. Even this is preferable to the mud of the unpaved streets farther out. However, the newer pavements of brick and fir blocks on end are well constructed and doubtless will soon be the rule. The great mileage of streets throughout the residence district, nearly all of which are still unimproved, makes the problem of their betterment a serious matter.

The street car service has been in much confusion, owing to a variety of ownership and to the use of different gages on different lines. The recent consolidation brings the principal lines under one control and very extensive improvements are being made. The Madrona Park and the Rainier Heights electric lines to Lake Washington have been rebuilt, with new ties and rails and much double track. Neither one runs farther down town than to the top of the James St. hill at Broadway. From here down the grades are so steep that a cable line is operated on the hill for about twelve blocks, dummies being run every few minutes with no trailers. The Jackson street line and the Renton suburban line are electric, but have track counterweights to assist up the steep grades. These consist of cast-iron weights on trucks underneath the track, with cables passing over sheaves at the hill top, so that the car going down can be hooked on and the ascending weight used to counterbalance the car. The weight then remains at the top of the hill until used by an ascending car.

The Renton line will probably be extended to Kent at an early date, and new lines are talked of to Tacoma and other points.

That portion of Puget Sound lying in front of the southern portion of the city is termed Elliott Bay, and at low tide the flats are bare. Considerable of this area has been filled in, and here are located most of the mills and shops, among which is the ship-building yard of Moran Bros. Co., who built the fast torpedo boat "Rowan" for the U. S. government.

They have just completed a wooden ship, the "G. W. Dickinson," of 1,200 tons, 215 feet long, 39.2 feet beam, 17.2 feet depth of hold, and at a cost of $140,000. She was built for the Alaska trade but has been sold to the government for a transport. This is the longest vessel ever launched sidewise on the Sound, and the [illegible] was very successfully performed, the hull landing [illegible] the water and sending a great sheet of water sidewise [illegible] the great discomfiture of many of the guests.

The ordinary repair of vessels and scows is [illegible] accomplished here, as the great range of tides [illegible] it possible to float a vessel over a gridiron, or [illegible] grillage, at high tide, and when the water falls it is [illegible] high and dry, accessible for cleaning and repairs.

The water supply has been drawn from Lake [illegible]ington by a pumping plant owned by the city; and [illegible] this will be continued, an additional gravity supply [illegible] be taken from Cedar River at a distance of 28½ m[illegible] and conveyed to the city by a pipe line.

The port of entry for Seattle is Port Townsend [illegible] the northeast coast of the Peninsula, and here has [illegible] up a thriving town of over 5,000 people. It is also [illegible] quarantine station and the county seat of Jefferson co[illegible].

The naval station is located at Port Orchard, [illegible] miles due west across the Sound from Seattle, in a [illegible]ation where an enemy would have a considerable hunt [illegible] find it. Here is the great timber dry-dock, 630 ft. [illegible]ngth and 130 ft. wide on top. While the altars are [illegible]tting away quite rapidly, they are easily removed [illegible] replaced. As this is done they are backed up with [illegible]oncrete and in time it will virtually be a concrete dock.

Substantial buildings have been erected, of brick and steel, for repair and workshops, and facilities are being provided to take care of the work to be done on the ships and cruisers.

One cannot form a just conception of the beauties of this Sound country except on close acquaintance, nor of its great resources and vast business possibilities. Tributary to it is the interior Northwestern country, with its timber, cereals, and extensive mines; Alaska, which is a great empire in itself; and the great Orient. So who can gainsay that in time there will be on Puget Sound the third greatest city of the Union.

C. E. F.

Seattle, April 17, 1900.

THE FILTER CRIB OF THE ALLEGHENY WATER WORKS.

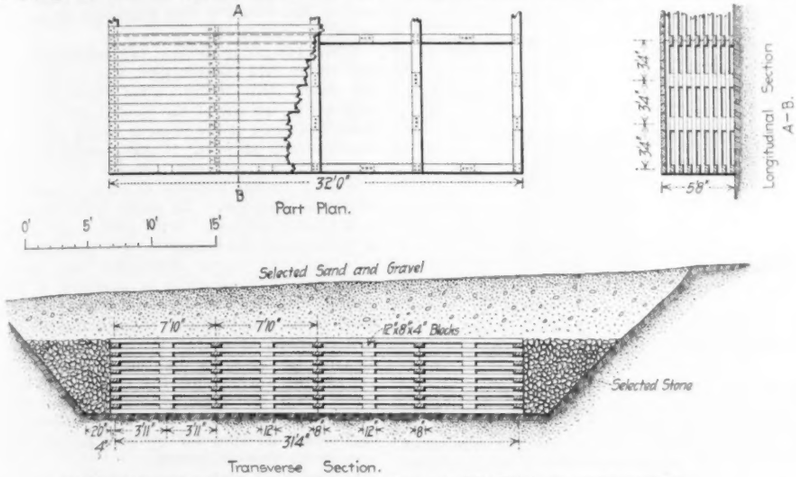
In some sections of the country, where recourse is had to very turbid streams for public water supplies, it is a common practice to seek relief by building filter cribs beneath the sandy or gravelly beds of the streams. This has been done at a number of water-works drawing their supply from the Allegheny River, near Pittsburg, Pa. (see Eng. News, May 10, 1894, and April 28, 1898). One of the largest developments of this kind was put in use by the city of Allegheny, in April, 1897. This crib is about 32 × 2,500 ft., thus covering an area of 80,000 sq. ft., over all, or nearly two acres. It has a tight top, but the sides, ends and bottom are open, as is shown in detail by the accompanying plan and sections.

The original works at Allegheny were built by the city in 1847. The pumping plant was located within the present city limits, near Herr Island and about 1½ miles above the junction of the Monongahela River with the Allegheny. The old intakes extended some 500 ft. into the river and as the reservoir capacity was only some 7,000,000 gallons, it was necessary to keep the pumps running without much regard to the turbidity of the water in the river. After many years of agitation it was decided to go up the river a number of miles to obtain a purer supply. Accordingly, a large pumping station was built at Montrose, Pa., and a steel force main constructed. The main is 60 ins. in diameter and about ten miles long (see Eng. News, Aug. 29 and Oct. 10, 1895), terminating in the distributing reservoir. In the hopes of improving the quality of the water, by reducing its turbidity, the filter crib already mentioned was constructed. The improvements were carried out under the direction of Mr. Robert Swan, at that time Supervising Engineer of the Allegheny Water-Works.

The crib was towed to position and sunk in a trench previously excavated. The trench was made larger than the crib and the space thus left was filled with stone. The whole crib was covered over with gravel and sand to a depth of about 5 ft. The depth of this material, however, varies from time to time, it is thought, with the formation of sand bars. Sometimes, it is said, ice forms on the sand over the crib, and on floating off carries some of the sand with it. On at least two occasions new material has been dumped over the crib. The depth of water on the sand above the crib is said to vary from 3 to 13 ft., according to the stage of the river, reaching the latter figure but

Four 36-in. intake pipes lead from the crib to the pumping station, the river wall of the latter being 300 ft. from the center line of the crib. The top of this pipe is about 5 ft. below the average water level in the river.

Mr. John L. Brown, Superintendent of the Allegheny Water-Works, states that so far there has been no trobule in getting as much water through the crib as has been desired; also that the crib gives a good clarification of the water. On the latter point more is said further on. The pumping records indicate an average daily consumption and waste of 30,000,000 to 35,000,000 gallons of water in 1899. From 1,000,000 to 10,000,000 gallons of water is still taken from the river at the old station. Allegheny has long been known as a city where an enormous waste of water is constantly occurring. It had, in November, 1899, only 12 meters in use. At that time, Mr. Brown said: "In a municipal plant you can't put meters in." This, it is hardly necessary to say, has not been the case in all cities, although Pennsylvania is very backward in both metering and thoroughly purifying its water supplies.



PLAN AND SECTIONS OF FILTER CRIBS, ALLEGHENY WATER-WORKS.
Robert Swan, Engineer.

Most of the information thus far given was obtained from Mr. Brown, at Allegheny, in November, 1899, by a member of the editorial staff of this journal. We are also indebted to Mr. Brown for the blue print from which the illustrations were prepared. Some facts have been taken from the Report of the Pittsburg Filtration Commission. That report contains brief descriptions of the Allegheny filter crib and other cribs in the vicinity and also a number of analyses of the water taken from the river over those cribs and from the cribs themselves. The following paragraph from the report (p. 237) sums up concisely the conclusions drawn from these studies of filter cribs; the Montrose crib being the one connected with the Allegheny works:

> In addition to those samples relating directly to the filter experiments, others were collected occasionally of the water supplies of Pittsburg, Allegheny, and of some of the neighboring places. It was desired especially to learn about the character of the water obtained from the various cribs in the Allegheny River. A study of the results given in the several tables will show to what extent these devices changed the character of the water, and it may be readily seen that, in general, the effluents from the cribs were clear and nearly free from suspended matter, except after an occasional very muddy period of the river; that the number of bacteria in the same was usually less than in the river, and that the hardness of the water from the cribs was materially greater than that of the samples of river water. It should be noted, in exception to the above, that the effluents from the cribs at Montrose and Millvale differed but very little, in regard to the items mentioned, from the river water.

This does not speak very well for the Allegheny filter crib. The detailed figures, however, and Mr. Brown's statement, indicate that some improvement in the water may be credited to the crib. It should be remembered that such cribs are designed primarily for clarification, and especially for tiding over the worst stages of the river. But after all, it seems very doubtful whether the results obtained by this crib are anything like adequate for the outlay occasioned by it. What it cost we cannot say, but the same amount would have made at least a start towards the construction of settling reservoirs, or storage reservoirs that would make it possible to shut down the pumps when the river is at its worst stages.

BOOK REVIEWS.

THE USE OF THE SLIDE RULE.—By F. A. Halsey, Associate Editor of the "American Machinist." New York: D. Van Nostrand Co. Cloth; 4 × 6 ins.; pp. 84; illustrated. 50 cts.

The scope of this book is indicated by the following extract from the preface:

> This book is mainly a reprint of a series of articles which originally appeared in the "American Machinist." It is to be taken as an instruction book rather than as a treatise. The engravings are true reproductions of the instrument, and show it properly set for solving the various problems. Such real difficulties as the slide-rule offers to the learner are carefully pointed out and the best methods of overcoming them are given.

The author describes the various types of slide-rule and slide rules for solving special problems.

THE RESISTANCE OF LOCOMOTIVES AND TRAINS.—The Water and Coal Consumption and Power of Locomotives. By Albert Frank, Professor at the Polytechnic, Hanover. Translated from the German by A. Bewley. Lawrence Asylum Press, Madras, India. Paper; 8 x 13 ins.; pp. 63; illustrated.

This monograph consists of an essay on the resistance of railway trains by Prof. Frank and its discussion by Mr. A. Schuebler, and Mr. Dieudonne. The essay is a record of the experiments made by Prof. Frank on train resistance in 1879-80, and the discussion and analysis of these experiments to determine a general formula. The two discussions, which follow the essay, review and criticise the experiments and the calculations made in evolving the formula.

BROOKLYN ENGINEERS' CLUB.—Proceedings for 1899; Constitution and By-Laws with List of Members. January, 1900. Office of Secretary, 191 Montague St., Brooklyn. Cloth; 9 × 6 ins.; pp. 233; illustrated. $2.

This club was organized in 1896, and the present work is the third of the annual publications. In addition to the reports of officers and committees, it contains the following papers by members: "Notes on Street Paving Material and Their Uses," Nelson P. Lewis; "A Half-Century of Sanitation," Wm. Paul Gerhard; "Electrolyses, An Unsolved Municipal Problem," H. S. Wynkoop; "Plans and Specifications," E. Duryea, Jr., W. V. Cranford, etc.; "Aluminum," Safford K. Colby; "The New York Building Law in re High Buildings," R. C. Strachan; "Recent Developments in Gas Engineering," H. K. Landis; Memoirs of Geo. W. Wundram and John H. Van der Veer.

PEOPLE AND PROPERTY.—By Edwin B. Jennings. The Abbey Press: 114 Fifth Ave., New York city. Cloth; 4½ × 7⅛ ins.; pp. 109; 50 cts.

The author of this little book is a well-known bridge engineer, having been Chief Engineer of the R. F. Hawkins Bridge & Iron Works at Springfield, Mass., for twelve years. In the volume before us he has given his impressions concerning some of the social and economic problems which are at present attracting such widespread attention. Most of his space is devoted to a presentment of the evils in modern civilization which Mr. Jennings holds grow from the unfair distribution of wealth. The remedy which he finally recommends for these evils is the public ownership of natural monopolies and the imprisonment of trust magnates. The disjointed style and the radical tone of portions of the book are likely to injure rather than aid the cause which the author has at heart.

THE THEORY AND PRACTICE OF SURVEYING.—Designed for the use of Surveyors and Engineers generally; but especially for the use of Students in Engineering. By J. B. Johnson, C. E., Dean of the College of Mechanics and Engineering of the University of Wisconsin, etc., etc. Fifteenth edition; revised and enlarged. New York: John Wiley & Sons. Cloth; 8 × 5⅝ ins.; pp. 837; illustrated. $4.

In this newest edition of Professor Johnson's well-known work, the principal additions and changes made are given as follows by the author: The G. C. Comstock field method of determining refraction correction in solar azimuth work; the use of the slide-rule and improved methods in using the transit and stadia. The chapter on Mining Surveying has been entirely rewritten by Prof. R. S. Stockton and Mr. E. P. Arthur, Jr., both accomplished mineral land surveyors. "The Manual of Instructions for the Survey of Mineral Lands" has been brought up to 1899; and an important addition is the "Rules for Restoring Lost Corners," as issued by the General Land Office.

MEMOIR OF HAYWARD AUGUSTUS HARVEY.—By His Sons. New York: 1900. Cloth; 8¼ × 5½ ins.; pp. 98; portraits and illustrations.

Hayward Augustus Harvey, the inventor of the Harvey armor-plate and of screw-making and other machines, was the son of Gen. Thos. W. Harvey, of Wardsboro, Vt., who was also early interested in the manufacture of screws, and in the iron and steel industry. H. A. Harvey was born in Jamestown, N. Y., Jan. 17, 1824. He first entered the employ of the New York Screw Co., of which his father was President, and about this time he made his first inventions—a machine for making blind staples, and a hay-cutter. After having been engaged in several other enterprises, he invented a full line of screw-making machinery, and organized the Continental Screw Co. in 1865, afterwards merged into the American Screw Co., with Mr. Harvey as Manager for a time. He then invented a machine for rolling screw threads instead of cutting them, and in 1881 he organized the Harvey Screw Co. The Harvey Steel Co. was started in 1886, for making file and tool steel. In 1889 he commenced his experiments in producing armor-plate, and in the same year he submitted a 6-in. plate for test at Annapolis. Mr. Harvey died, however, in August, 1893, before the organization for making and selling the new armor-steel was perfected. The memoir gives a full history of the legal controversy over the patents and the adoption of the Harveyed armor-plate in the United States and in Europe.

TECHNIC OF MECHANICAL DRAFTING.—By C. W. Reinhardt, Chief Draftsman, Engineering News. Engineering News Pub. Co., New York, N. Y. Cloth, 10¾ × 8 ins.; pp. 36; 61 text illustrations and 10 full-page plates. $1.

The character and scope of this book is described by the author in his preface as follows:

> In the following pages the writer has endeavored to give to the busy draftsman a thoroughly practical, commonsense guide to good mechanical drafting; no attention whatever has been paid to the mathematics involved.
>
> Many draftsmen, after having carefully laid out their drawings, commit the error of slighting them in the execution; sometimes to such an extent as to render them all but illegible to the men in the shops. The constructing engineer frequently finds himself handicapped in a similar manner. After wrestling with the meaning of portion of a drawing he finds that other sections or elevations do not correspond with the part first consulted. He has to make his own deductions, and in reading between the lines, as it were, perhaps finally arrives at some sort of conclusion regarding the correct shape of the parts outlined, or, as a last resort, goes in search of the draftsman. Such inconsistencies, if they may be termed so, unnecessarily increase mental labor in reading and interpreting a design, and it will be the special province of this book to eradicate them.
>
> While deprecating any needlessly elaborate finish, the writer advises the use of just sufficient shading and finishing touches to render a drawing thoroughly comprehensible and to preclude any possible ambiguity.
>
> The illustrations in this work, quite a number of which has appeared in the columns of Engineering News, are inserted to demonstrate the points involved, and have been reduced more or less in size, so as to save space. They may, however, be copied by enlarging to about three or four times their linear dimensions.
>
> It is, of course, to be understood that this book is not a manual for beginners exactly; it serves its purpose best where used by the draftsman who is familiar with the mathematical principles of mechanical drafting. It will, then, as the writer hopes, prove a valuable aid to the rapid production of neat, correct and legible drawings.

U. S. GEOLOGICAL SURVEY.—Hydrography of Nicaragua. By Arthur Powell Davis. Extract from 20th Annual Report, 1898-99. Part IV. Hydrography. Washington, D. C. Paper, 11⅝ × 7⅝ ins.; pp. 369-660; illustrated.

This report takes up the general topographic features of Nicaragua, and particularly discusses the basin of Lake Nicaragua. According to a recent study of the geology of this region by Dr. W. C. Hayes, this lake has an area of 2,975 sq. miles, with a greater length of 100 and extreme width of 45 miles. Dr. Hayes says that in Tertiary time the continental divide was east of the site of the present lake, which did not then exist, and the lowest depression in the divide was near Castillo, where the San Juan now cuts through. A bay then extended from the Pacific to the present site of the volcanoes of Ometepe and Madera. In

post-Tertiary time the eruption from these volcanoes and the line of volcanoes running from there to the northwest filled the bay and cut off all drainage towards the Pacific; the rainfall then collected in this basin and began to form the lake. The water gradually rose until it reached the depression at Castillo, and then ran over towards the Atlantic slopes and gradually cut down the channel of the present San Juan River, draining 15,000 sq. miles of territory. The lowest gap in the divide west of Lake Nicaragua is 152 ft. above sea-level, or about 50 ft. above the lake-level. Dr. Hayes says that this western depression has been steadily moving eastward under the erosive action of the rapid streams flowing into the Pacific; and, if not disturbed by igneous agencies or canal builders, Lake Nicarauga, in the remote future, would empty into the Pacific and the continental divide be again shifted to the east of the present lake.

The report deals in detail with the Nicaraguan rainfall; with a 19-year record at Rivas, west of the lake. The maximum rainfall so far recorded was in 1890 at Greytown, when nearly 300 ins. fell in one year, and 1892 almost equalled it. The mean annual rainfall is 70 ins. at Rivas and about 250 ins. at Greytown. The evaporation observations seem to indicate a daily evaporation of about 0.2 in. in the dry season in the neighborhood of Lake Nicaragua. The report further deals with the agricultural products and population—the latter is placed between 300,000 and 400,000, with 50 Indians, 1 negro, 45 mixed blood and 4 whites to each 100 of population. The ship-transit problem is treated at length, with a short history of each of the many projects; these number 19 in all. The report concludes with discharge measurements for Lake Nicaragua and the various rivers affecting the Isthmian canal projects.

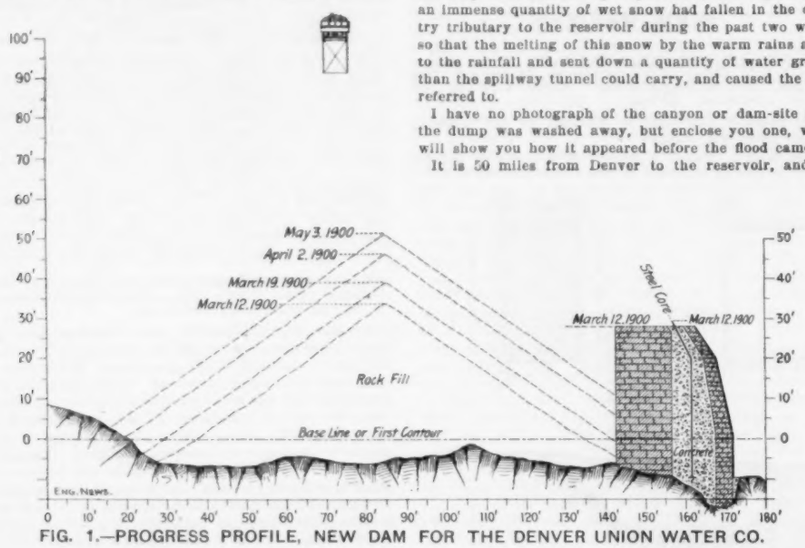


FIG. 1.—PROGRESS PROFILE, NEW DAM FOR THE DENVER UNION WATER CO.

ACCIDENT TO THE PARTIALLY BUILT DAM OF THE DENVER UNION WATER CO.

Early on the morning of May 3, a sudden rise in Goose Creek washed out some of the rock fill portion of the dam now being built to increase the water supply of Denver. Mr. C. P. Allen, Chief Engineer of the Denver Union Water Co., has very kindly responded to our request for particulars of the accident by sending us a progress profile of the dam and two views, taken before the accident. The profile, Fig. 1, shows the general scheme, including the bridge across the narrow canyon for dumping in the rock fill. This bridge also shows in the two views, both taken on the up-stream side. Fig. 1 is a rear view, and Fig. 2 was taken from a more distant point. Mr. Allen's description of the structure and the accident is as follows:

The plan of the dam is a masonry wall at the base of the up-stream side, 28 ft. in height above the base line, in which is imbedded a ⅜-in. steel plate extending across the canyon, and bolted into the side wall of the same. The face wall was to be discontinued at the point shown in the cross-section. The steel face was to extend the entire height of the dam, namely 210 ft., with a concrete backing 2 ft. in thickness between a hand-laid wall and the plates, which were to be riveted to 6-in. I-beams imbedded in the concrete. The hand-laid wall was 15 ft. in thickness and this was supported by a loose rock fill. The loose rock fill was completed to about 50 ft. in height, or 19 ft. above the permanent or water-tight construction. The unprecedented rain and cloud-burst caused the lake to fill above the masonry and steel plates, and to the top of the loose rock dump, so that a torrent of water poured over the top and took out a portion of the dump, but left the completed portion of the dam intact and uninjured. The rainfall for the month of April was 9 ins., which was almost equal to the total precipitation of some years, and an immense quantity of wet snow had fallen in the country tributary to the reservoir during the past two weeks, so that the melting of this snow by the warm rains added to the rainfall and sent down a quantity of water greater than the spillway tunnel could carry, and caused the raise referred to.

I have no photograph of the canyon or dam-site since the dump was washed away, but enclose you one, which will show you how it appeared before the flood came.

It is 50 miles from Denver to the reservoir, and the railroad tracks in Platte Canyon, and this would [illegible] have happened even if our loose rock dump [illegible] not broken, as the heavy rains in the canyon wo[illegible] have raised the river. The flood in the Platte River [illegible] Denver, even with the additional water from our [illegible] was not as high as during other floods, notably [illegible] one in 1894, which originated in the foothills this s[illegible] our reservoir site.

wafer which was let loose at 3:30 a. m., of May 3, did not reach Denver until 10 o'clock that evening. Platte River was in flood at this time and this extra amount of water only raised it in Denver about 18 ins. The raise lasted about three hours and so far as we are advised no damage to person or property resulted, except a slight damage to

THE DEVELOPMENT OF THE ELECTRIC DRI[illegible] FOR COTTON MILLS.

At the meeting of the Southern Cotton Sp[illegible]ers' Association on May 10, Mr. Sidney B. Paine, [illegible] the General Electric Co., read a paper dealing w[illegible] the development of the electric drive for ope[illegible]ing cotton mill machinery. Some of the facts b[illegible]ught out by Mr. Paine in this paper are of gener[illegible] interest to engineers.

After describing several representative in[illegible]vidual cotton mill installations, and giving a [illegible] of the textile mills of the United States showin[illegible] the increase in the use of the electric drive, the [illegible]aper described some of the reasons which had led [illegible] manufacturers to adopt it. It was pointed out that the electric system did not increase the original investment by the amount of money paid for the electrical equipment. In many items the first cost was greatly reduced. With electric drive, no belt or rope tower was required. The large main drive was omitted. Being subdivided into short sections, the shafting could be operated, if desired, at higher speeds, and smaller driving pulleys used. Subdivision was obtained without the use of friction clutches, as on the mechanical system. Ordinarily no separate lighting dynamo was required, the current for the electric lights being taken from the same generator which supplied current to the motors. In a large mill these savings would go very far towards paying the first cost of the electric system.

As compared with a small mechanically-driven

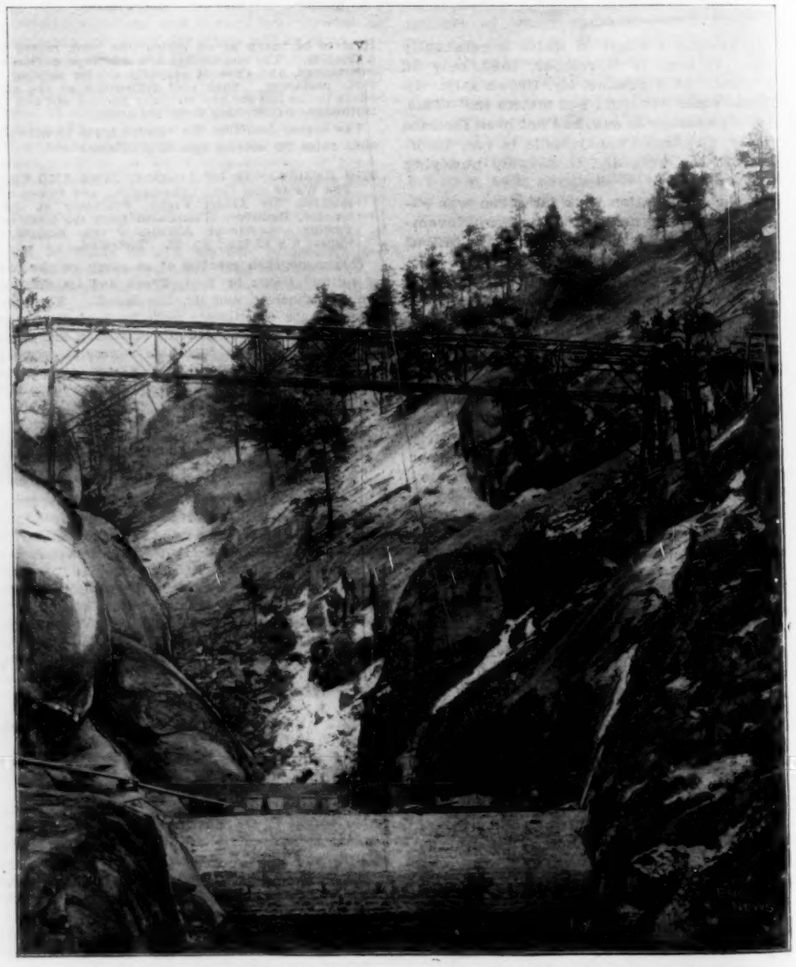


FIG. 2.—NEAR VIEW OF DAM UNDER CONSTRUCTION, FROM UP-STREAM.

where provision is made for subsequent enlargement by extension of the main building, there are many other savings in addition to those just mentioned. In such mills the belt tower ought to be wide enough for the original building, and also for the proposed extension. The driving wheel of the engine must have sufficient face for the larger belt. Sometimes one side of the cross compound was installed, the other cylinder being added when the enlargement was made. For the sake of higher economy as an alternative, half of a double compound engine was sometimes used, although this alternative was seldom adopted. The first plan was open to the objection of large fuel consumption, especially as the date of the enlargement was uncertain. Both plans provided a single crank engine, which was objectionable and uneconomical. Another plan was to install the permanent engine complete at the start and operate it at reduced steam pressure. But no matter which of these plans was followed, the extent of the enlargement, as well as the character of the goods to be manufactured, had to be determined in advance. If a mill was designed for fine goods, it could not go into course numbers and enlarge to the extent originally contemplated. The same limitations applied to shafting, which had to be made sufficiently large to carry the subsequent additions as well as the first installment. It might be years before an extension was made, yet the burden of first cost and uneconomical operation must be borne by the first mill. More than that, it might be found that all provisions made for enlargement were inadequate.

In mills driven by electricity the solution of these problems was much more simple. All that was necessary was to add a second engine and generator with its complement of motors when the building was extended. The extent of the addition and the character of the goods to be manufactured need not be considered until the time when such extension was necessary. Furthermore, the first cost of the electrically-driven mill would probably be less than that of the mechanically-driven mill in which provision for enlargement was made. The cost of the engine and its foundations for the latter mill would be considerably higher than that for the mill using the electric system. The shafting in the mechanically-driven mill being much larger than was necessary for the present building, would be very much more expensive than that required in the electrical driven mill.

Dealing next with the question of economy and flexible operation, the paper claimed the following advantages for the electric system over the mechanically-driven system:

Subdivision into independent sections, each driven by its own motor. Variations in speed in one section, due to slipping on such belting as is still retained, are not communicated to other sections.

The mill is not dependent upon one main drive; therefore, there is less liability of shut down due to accident within the mill. If the shut down occurs, it is only partial and local.

It permits the operation of one or more sections overtime without driving the shafting in any other sections. There is less difficulty in keeping the shafting alined. It therefore follows that there is a saving in labor and less power is wasted.

Steadiness and uniformity of speed is occasioned by omission of many pulleys and belts, and results in greatly increased production. It also necessitates fewer repairs on the machinery, especially the looms. The diameter of the shafting is determined principally by the pull of the belt between hangers. Torsion need not be considered to the same extent as on the mechanical system. All pulleys and hangers are, therefore, of the same bore, except on those lengths of shafting which carry the receiving pulleys.

On large plants the loss between the prime mover and the shafting driven by the motors will vary from 16% to 18%. In other words, 82% to 84% of the power delivered by the engine or wheel will be delivered by the motors. Great claims are advanced for the mechanical system on this point. It is impracticable, however, accurately to measure the losses where that system is used, for the reason that you cannot determine the friction of the shafting while carrying the load of machinery under full production. The power lost by slipping of belts and by increased pressure on bearings cannot be ascertained, except approximately.

Improved light and ventilation are obtained by removing the power house away from the mill and by omission of the belt tower. Power in any section may easily be augmented, or addition may be made to the mill without stopping the mill or interfering with the existing shafting. It not infrequently happens, especially in older mills, that it becomes necessary to replace the main engine. It is either worn out or machinery has been added to such an extent that it is overloaded. In mechanically driven mills in such cases it will be necessary to shut down the mills. This will result in the loss of profits and of fixed charges during the shut down, and, what is quite as important, the scattering of the employes. With the electric drive no stoppage would occur as long as the old engine could be operated. A new engine and generator would be installed at any convenient point and either supplement the old engine or displace it entirely.

The power to operate any section may be readily measured. In the Olympia Mills, at Columbia, S. C., and in the Lancaster Mills, at Lancaster, Mass., this will be continuously indicated by instruments placed in the engine room. These indicators enable the engineer in charge to detect at a glance any unnecessary consumption of power due to poor alinement of shafting, improper oiling, etc. The actual power consumed by any machines can be measured at any time by separate portable instruments.

The generating plant may also be subdivided into two or more units. This insures against a complete shut down in case of accident and also permits economical operation under partial loads. This also allows one or more sections of the mill to be operated from either generating unit. All other sections will remain idle. This is not possible with the mechanical system, even though the generating plant may be subdivided. Finally, as the location of the buildings is determined without reference to the location of the power house, they may be placed together and so arranged as to facilitate manufacture and reduce the expense of supervision.

FIG. 3.—MORE DISTANT VIEW OF DAM UNDER CONSTRUCTION, FROM UP-STREAM.
(The rock fill may be seen just beyond the masonry base and beneath the dumping bridge.)

ASPHALT COATINGS FOR WATER PIPE.

Within recent years there have been many attempts made to obtain some kind of coating for water pipes which will be superior to the ordinary tar coating. The principal requirements for such a material are as follows: (1) it must adhere permanently to the metal; (2) it must resist the attacks of water, acids and electric currents, so as to prevent corrosion by rust, chemical action or electrolysis; and (3) it must give a smooth finish to the pipe.

A material which is claimed to meet all these requirements is an asphalt composition known by the trade name of "mineral rubber" asphalt, which is one of the Utah asphalt products. This material was adopted in 1897 for the reservoir pipe lines at Minneapolis, Minn., the contract for which, amounting to $343,726, was awarded to the T. A. Gillespie Co., of Pittsburg, Pa. The specifications for the work were prepared by Mr. F. W. Cappelen, M. Am. Soc. C. E., who was City Engineer at that time (and until Jan. 1, 1899), and contained the following clause as to the coating:

After testing to the satisfaction of the engineer, the pipe shall be thoroughly dried and cleaned, and heated in a suitable oven to 300°F., after which they are to be thoroughly coated by dipping vertically in a bath of mineral rubber asphalt, manufactured by the Assyrian Asphalt Co., Chicago, Ill., or such other material equally as good as the engineer may designate. This coating must be smooth, hard yet tough, elastic and durable; it must be free from blisters and bubbles.

In connection with these specifications, tests were made of five different coatings, as follows: (1) Mineral rubber asphalt; (2) Trinidad asphalt, mixed with dead oil, used by the Hugo Iron Works, of Duluth, Minn., for the new 42-in. steel pipe line in Duluth (Eng. News, May 5, 1898); (3) California asphalt from the Waldorf mines; (4) the same California asphalt, mixed with about 40% of maltha (also used at Duluth); (5) pipe dip from the works of Dennis Long & Co., of Louisville, Ky. For the dipping test an oven was built of brick, and two 8-in. iron pipes bricked in so as not to be exposed on the inside to any smoke or flame. Into these pipes 4-in. pipes were placed to be heated to the desired temperature. These pipes were thoroughly cleaned by pickling in diluted acid before heating. The coating material was heated simultaneously, and when pipe and coating had the desired temperature, the pipes were dipped vertically. Some pipes were dipped once, and some dipped twice, the second dip being made quickly after the first, and thereafter the dip was either placed in ice water and allowed to cool therein, or was cooled without being put in water. After cooling, the coating was subjected to blows from a hammer to test the elasticity of the material.

The results of the tests, with other particulars as to the behavior of the materials, taken from Mr. Cappelen's report, are given below:

Coating.	Temperature, °F. Pipe.	Coating.	Pipe dipped.
Mineral rubber.....	400	400	Twice; then put in ice.
" "	400	400	Once; " " "
" "	300	300	Twice; " " "
" "	300	300	Once; not put in ice.
Trinidad asphalt.....	300	300	Twice; then put in ice.
" "	300	300	Once; " " "
" "	300	300	Twice; not " "
" "	300	300	Once; " " "
California asphalt....	350	350	Twice; then " "
" "	350	350	Once; " " "
" "	350	350	Once; not " "
Cal. asp. and maltha.	300	400	Twice; then " "
" " "	300	400	Once; " " "
" " "	300	400	Twice; not " "
Dennis Long.....	300	300	Twice; then " "
" "	300	300	Once; " " "
" "	300	300	Twice; not " "

Mineral Rubber Asphalt.—The coating covered the pipe splendidly in all cases, was somewhat thicker for the 300° temperature, and stood the hammer test perfectly. The material is so elastic that by cutting into the coating and entirely removing some of it, the opening can be covered by simply hammering the edges around the space, so that it is impossible to see the joint. The coating did not foam even up to a temperature of 700°F.

Trinidad Asphalt.—The coating remained sticky after application, in all cases evidently due to the dead oil. The hammer test was made some days later, showing some slight flaking, but at the same time indicating consider-

able elasticity. That the coating loses its stickiness must be due to evaporation of the dead oil. The mixture when heated foamed considerably, evidently due to presence of dead oil and moisture.

California Asphalt.—Coating was very nice, but flaked badly for hammer test in all cases.

California Asphalt and Maltha.—This coating was very nice, but flaked slightly in all cases. I made this mixture myself, having had some experience with the two materials constituting the same. The high percentage of maltha is required to overcome the brittleness of the asphalt.

Dennis Long & Co.—This coating did not stand the hammer test, and when hot foamed considerably. In all cases, but particularly where the coating flaked off, a thin secondary coating could be seen next to the pipe. This same condition was found to exist on some of the New Jersey Water Co.'s 48-in. steel pipe for the Newark supply when it was uncovered in 1897. Mr. Sherrerd, the engineer in charge of the water department of the city of Newark, N. J., considered this secondary coating to be a combination of sesqui-oxide of iron with protoxide, or what would be chemically equivalent to $Fe_2O_3 + FeO = Fe_3O_4$, a more stable compound which would prevent further oxidation, and is probably due to some chemical action which takes place when the hot pipe is dipped in the asphalt bath. Where nothing but this coating was found on the Jersey pipe line, no further oxidation was discovered.

Some 20 iron plates, about ⅛-in. thick and 6 ins. square were treated in a similar manner to the pipes, with the same results. Tests were then made with various acids to see the effect upon the coating on the plates, with the following results: The mineral rubber coating was not affected by muriatic acid, nitric acid or sulphuric acid. The Trinidad coating was not affected by muriatic acid, but was affected by the others. The California and maltha coating was affected slightly by muriatic acid, but very perceptibly by the others. The California straight coating was not affected by muriatic acid, but was affected by the other acids. The Dennis Long coating was affected by all three acids.

Finally, the three best coatings were analyzed, with the following results:

	Mineral rubber.	California and maltha.	Trinidad.
	%	%	%
Petrolene (soluble in petroleum ether)	75.71	70.66	43.08
Asphaltene (soluble in boiling turpentine and chloroform)	23.59	12.35	14.67
Total bitumen	99.30	83.01	57.75
Coke and organic matter*	0.49	2.61	21.58
Ash (mineral matter)	0.21	11.95	1.05
Moisture and volatile, 100° C.	....	2.43	19.62
Total	100.00	100.00	100.00
Specific graviy	0.97	1.13	1.20

*Not bitumen.

The analysis of the Trinidad mixture was very tedious and required several days' time. It was repeated to make sure of the result, which is correct as above.

Judging from these various tests, I was convinced that the mineral rubber coating is the best, and, judging from the other information at hand, it is probably the best coating ever put on the market, not barring the so-called Sabin japanning process.

Mr. Cappelen informs us that the coating worked very well in the field, very little abrasion being found after the pipes had been transported from Pittsburg to Minneapolis. In 1898, he reported at the convention of the American Water-Works Association that the mineral rubber coating appeared best after the test pipes had been exposed one year in the air. Since that time the pipes have been immersed in running water for over 18 months. He made a further examination in February, 1900, and found that all the different coatings had preserved the pipes. Where no coating had been applied, corrosion had taken place, and where he had previously removed small parts of the coating, tubercles had formed, in some cases ½--in. in thickness. A great many blisters had formed in the Trinidad coating. These blisters were brittle and corrosion had set in underneath. This coating was brittle. The three samples of California straight coating were good; no blisters had formed, but the coating was brittle. The California asphalt and maltha coating had started to blister, but was not so hard as the Trinidad coating. The Dennis Long coating was good; a few small blisters had formed on one sample, but there was no corrosion underneath. On the mineral rubber pipe coating no blisters of any kind had formed, nor had the coating become brittle. He has now immersed the test pipes in one of the city's sewers in order to see what the effect will be.

The mineral rubber coating was used last year on eight miles of 26-in. steel pipe at Butte, Mont., and 34,000 ft. of 42-in. steel pipe at Seattle, Wash.

The mineral rubber asphalt coating is manufactured from asphalt from mines in Utah by the Assyrian Asphalt Co., Tacoma Building, Chicago, Ill. For painting field riveted work, joints, or places where the original coating has been damaged in transportation, a special paint is used, made from the same material, but in the form of a thick air-drying paint. Another variety of the same material is adapted for reservoir linings, being used either pure or mixed with silica sand. It is claimed that this lining will not flow or run even at a temperature of 200° F.

SILICO LAKE RAILWAY, AND THE GREYTOWN BREAKWATER OF THE NICARAGUA CANAL CO.

We are indebted to Mr. Henry Welles Durham C. E., for the photographs here reproduced, showing some interesting conditions at the Greytown end of the proposed Nicaragua Canal.

Fig. 1.—Cut on the Silico Lake Railway, Nicaragua.

The first view shows a cut on the Silico Lake Railway; built in 1898-99, to connect the San Juan River, above the head of the delta, with Silico Lake and the San Juanillo River leading to Greytown. This railway and the lake route avoid the necessity at low water of crossing the Greytown bar, running 20 miles down the coast and entering the San Juan by the Colorado mouth.

The railway is 6½ miles long, and follows a line of isolated, low clay hills, stretching from the river to the northward around the lake; the surrounding country is flat and swampy. It was built under the superintendence of Mr. Louis Wichmann, General Manager of the Carribean & Pacific Transit Co., which controls steam navigation on the San Juan River. The rolling stock includes a light Porter locomotive, 8 flat cars and [illegible] passenger cars; the gage is 2½ ft., with 30-[illegible] rails; and the total cost, including terminals and buildings, was about $130,000. The excavation is said to have cost 50 cts. per cu. yd.

The deepest cut is that shown in the photograph. It is 40 ft. deep, and less than 200 ft. long, with side slopes of 4 on 1. The material is a stiff clay, red at the surface and turning to a blue color as it nears the bottom of the cut. These steep slopes stand the heavy rains perfectly, and there is no frost to disintegrate them. The cut has been finished several months, and showed no tendency to slide in a region where the annual rainfall is nearly 300 ins., and 12 ins. rainfall has been recorded in one day.

The other view shows the present condition of the breakwater, which was built by the Maritime Canal Co. It is now seven years since work upon it was abandoned. The view is taken looking seaward from the Greytown lighthouse; and to the right is seen the sand piled against this breakwater by the littoral currents coming from the southeast. This beach-building has continued until it now reaches the end of the breakwater, which is about 1,000 ft. long. On the left is seen the tongue of sand closing what was formerly the entrance to Greytown harbor, which is now a shallow lagoon.

The two points of interest in this exhibit, so far as a ship canal in this region is concerned, are the following: This stiff clay soil will stand at a very steep slope in canal cuttings. The stability of this clay under extraordinary rainfall conditions is also shown along the railway to the Deseado River, built by the Canal Co. nearly ten years ago. Until very recently the pick-marks were still visible in the latter cuttings. The rapid progress made in beach-building in seven years is also instructive; though it must be said that the work on the breakwater was stopped before deep water was reached. In 1891 there was a steamer channel, about 9 ft. deep, along the north side of the jetty. This has now become completely blocked by the sand passing around the head of the structure. Judging from the line of breakers, shoal water now extends far beyond the head of the present breakwater.

FIG. 2.—PRESENT CONDITION AT THE BREAKWATER BUILT FOR THE

GREYTOWN END OF THE NICARAGUA SHIP CANAL, IN 1890-91.

A NEW PLAN OF INTERLOCKING PROTECTION FOR RAILWAY GRADE CROSSINGS.

In a paper read before the Railway Signaling Club, on May 8, Mr. J. T. Vernon, Supervisor of Signals, Eastern District, New York, New Haven & Hartford R. R., suggests an improvement in the usual method of protecting grade crossings by interlocking, which employs derailing switches. Briefly stated, the change proposed consists sim-

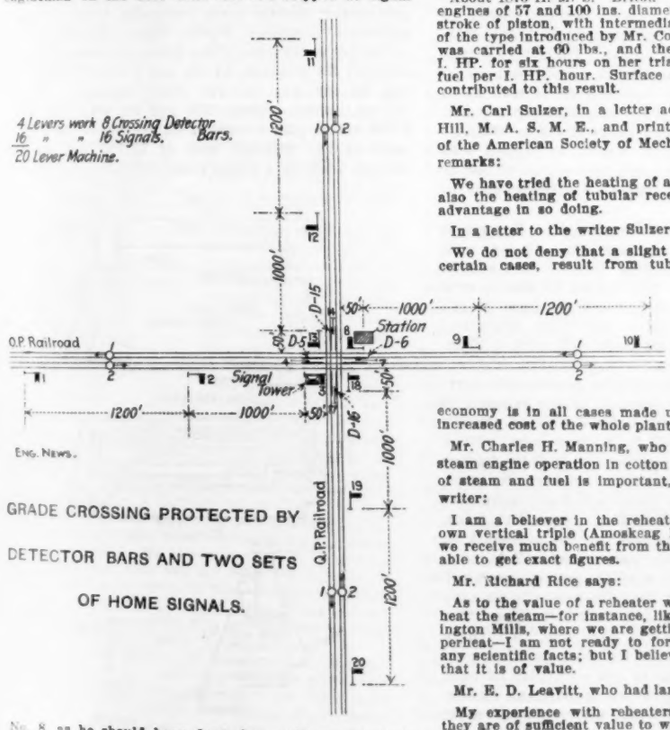
...n substituting detector bars for the usual ...ing and in adding a second set of home signals ... signals already usually employed. The ... arrangement is outlined quite clearly by the ...panying sketch, and the advantages claimed ... are given by Mr. Vernon in his paper as ...

...rossing is protected by detector bars and signals, ... by derailing switches and signals. Detector ... each 45 ft. long, are located as near as possible to ...ssing. The left-hand movement is governed by a ...signal which is located 50 ft. from the crossing. ...changing the right to the crossing from one road ...other, the detector bar levers must be reversed ...nal signals can be given to cross from either di- ...either for a right-hand movement or a left-hand ...ent.

...right-hand movement is governed by a second ...signal located 50 ft. from the crossing, a first home ...,050 ft. and a distant signal 2,250 ft. from the ... The locking combination is so arranged that ...signal, either No. 3, 2, 4, 7, 8 or 9 locks signal Nos. ..., 14, 17, 18 and 19; and one signal, either No. 12, ..., 17, 18 or 19, locks signals Nos. 3, 2, 4, 7, 8 and ... distant signals lock their home signals in their clear ...tions, as in common practice.

...train approaching a crossing on track No. 2 of the ...R. R. will have all three signals clear to cross over, ...where it may stop with its rear end 50 ft. clear of the ...crossing, which is just far enough to clear dwarf signal No. 7, but until the train has reached this point, no signals can be given for a train to approach on the other road. When the first train has cleared dwarf signal No. 7, however, the detector bars may be reversed and signals given for a train to advance to the station from either direction on the Q. P. R. R. Therefore it is both safe and convenient for both trains to stand at the station and transfer passengers and baggage, and at the same time either train or both trains may depart when they are ready to do so. It should be borne in mind that when a train is standing on or within 50 ft. of the crossing on the Q. P. R. R. it is impossible for the towerman to clear any signals for trains to approach from either direction on the O. R. R. R. Or if a train is standing on or within 50 ft. of the crossing on the O. R. R. R., he cannot clear any signals for a train to approach from either direction on the Q. P. R. R.

We shall now follow the movements of two trains approaching the crossing, the first on track No. 1 of the O. R. R. R. and the second train on either track No. 1 or No. 2 of the Q. P. R. R. The first train having only one signal, No. 9, clear for him, will advance to signal No. 8, which will be at danger and should bring the train to a full stop. Then the towerman must put back his detector bar levers Nos. 5 and 6 before he can pull detector bar levers Nos. 15 and 16 for the freedom of any signals to approach the crossing on the Q. P. R. R. If the engineman on the first train had not stopped at signal



GRADE CROSSING PROTECTED BY DETECTOR BARS AND TWO SETS OF HOME SIGNALS.

No. 8, as he should have done, he would run his train on to detector bar No. 6, thus preventing the towerman from changing his combination or giving any signals for a train to approach on the other road until after this train had either backed up to clear signal No. 8 or else advanced to clear dwarf signal No. 4.

Considering the case of an express passenger or freight train approaching the crossing from either direction on the O. R. R. R., the engineman and crew being accustomed to having clear signals at this point and not finding the distant signal clear, attributes it to neglect on the part of the towerman. The train proceeds at a fair rate of speed to the first home signal, which is also against them. The engineman then applies his brakes, and he has a distance of 1,000 ft. in which to stop before reaching the second home signal. In this case he will not derail his train nor yet do any damage to persons or property by running past the first home signal. At the same time the towerman's duty should be to report the engineman for disregarding the first home signal and the matter should be dealt with in the same manner as if the train had been derailed.

A new towerman, or one of nervous or excitable disposition is not so dangerous at this crossing as he is at a crossing protected in the ordinary manner in case he has trouble in getting his combination or clearing his signals. Knowing that no trains are approaching on the intersecting road, he takes the liberty of giving a hand signal to pass the first home signal, and the engineer, seeing the second home signal at danger, will proceed cautiously until within speaking distance of the towerman, when he may be told what the trouble is and that he may proceed. While the arrangement according to the accompanying sketch is more convenient for train movements, and in my opinion a safer one than that which employs derailing switches for a grade crossing, I believe that derailing switches are the proper protection for main lines approaching drawbridges and for sidetracks leading to main lines. If a train runs past a stop signal approaching an open draw it is better that it shoud go on the ground than that it should run into the open draw. It is also better that a car should be derailed from a sidetrack than that it should run on to a main line.

REHEATERS IN MULTIPLE-CYLINDER ENGINES.*

By R. H. Thurston, M. Am. Soc. M. E.†

Reheaters in multiple-cylinder engines have been employed by various designers and builders from a very early period in their history. Perhaps the first to use this device was John Bourne, who tells us that he employed it in 1839. In later years Mr. Cowper, the distinguished English hydraulic engineer, employed the device, and in this country as early as 1869 it was used by the late Henry R. Worthington in his Philadelphia pumping engine and on many later engines. It was used by Mr. Corliss and also by Mr. Leavitt on his Calumet and Hecla Mining Company engines (1874).

The first mention of this apparatus in engineering literature, so far as the writer has observed, occurs in the little book by John Bourne, "Recent Improvements in the Steam Engine." Bourne says:

In some cases, where double-cylinder engines are employed, a superheater is introduced between the high-pressure cylinder and the low-pressure one, so as to replace the heat lost by radiation and by the production of power in the high-pressure cylinder. This arrangement, introduced by me into a steamer, about 1859, was exemplified in various engines shown at the International Exhibition in 1862, and promises to be very serviceable in cases where a small consumption of fuel is an object of paramount importance.

About 1870 H. M. S. "Briton" was fitted with compound engines of 57 and 100 ins. diameter of cylinder and 33 ins. stroke of piston, with intermediate reservoir and reheater of the type introduced by Mr. Cowper years before. Steam was carried at 60 lbs., and the engines developed 2,018 I. HP. for six hours on her trial, consuming 1.98 lbs. of fuel per I. HP. hour. Surface condensers and reheating contributed to this result.

Mr. Carl Sulzer, in a letter addressed to Mr. Hamilton Hill, M. A. S. M. E., and printed in the "Transactions" of the American Society of Mechanical Engineers in 1897, remarks:

We have tried the heating of all jackets by direct steam, also the heating of tubular receivers, but have found no advantage in so doing.

In a letter to the writer Sulzer Brothers say:

We do not deny that a slight gain in economy may, in certain cases, result from tubular reheaters, but this economy is in all cases made up by the interest on the increased cost of the whole plant.

Mr. Charles H. Manning, who has a large experience in steam engine operation in cotton mills, and where economy of steam and fuel is important, states in a letter to the writer:

I am a believer in the reheater, and know that in our own vertical triple (Amoskeag Mills, Manchester, N. H.) we receive much benefit from them; but we have not been able to get exact figures.

Mr. Richard Rice says:

As to the value of a reheater which is sufficient to superheat the steam—for instance, like the engine at the Washington Mills, where we are getting from 50° to 60° of superheat—I am not ready to form an opinion based upon any scientific facts; but I believe from what I have seen that it is of value.

Mr. E. D. Leavitt, who had large experience, says:

My experience with reheaters has simply proved that they are of sufficient value to warrant their use.

Mr. A. K. Mansfield writes:

We have been using reheaters to a considerable extent, and have recommended their use with the belief that they are of somewhat more advantage than the steam jacket, which we like to avoid in commercial engines, as they add complication and expense.

Mr. Edwin Reynolds says:

As a matter of fact, the best results we have ever obtained have been on engines where these reheating receivers have been used; but to what extent they effected the results we are unable to say.

Mr. Charles C. Worthington writes:

We have made enough tests in the direction of doing away with reheating to determine positively that the more reheating we get the better the engine works. * * * The stroke is more absolutely uniform the drier we make the steam. * * * The more we do away with the disturbances of entrainment and irregular condensation the nearer we come to the ideal conditions, and superheating and reheating are in proper line for this. We find that the engine is sensitive to any attempt to reduce the pressure in the jackets or the reheater, even if only done in the low-pressure cylinder and the last reheater, and our observations seem to indicate—although they have not been made with as much care as the importance of the subject demands—that a loss of economy follows any such attempt.

The Sibley College quadruple-expansion experimental engine is fitted with reheaters, and although operated at 500 lbs. pressure and upward, and although the superheating effected is but moderate, it is supposed that a sensible amount of gain is due to their use, and that the reported efficiency of the engine, a consumption of less than 10 lbs. of steam, or below 11,000 B. T. U. per hour per HP., comes in some degree from this construction.

The triple engine of the Massachusetts Institute of Technology, refitted with reheaters of variable effective area of reheating surface, is reported to have given the following results in preliminary trials: With reheaters out of use and developing 88 to 90 I. HP., from 15.95 to 16.02 lbs. of steam per HP. per hour passed through the engine. With 84.93 I. HP., and with one reheater in use, the consumption was 15.87. With 75 and 95 HP. developed, the two reheaters being in use, 14.9 and 14.7 lbs. were used. With 105 and 107 I. HP. developed, the consumption was 14.7 and 14.5. Cylinder jackets were not in use. Net saving, 8%.

The triple-expansion experimental engine of the Sibley College laboratory shows very little, if any, advantage in the use of the reheaters in conjunction with the jackets on the cylinders, but there is an evident more or less complete substitution of the one device for the other where used alternately, and the required improvement in quality of steam to insure the exceptional efficiency of that engine noted under its most favorable conditions of operation is approximated with either arrangement. Preliminarily well-dried steam passing through a superheater is certainly an effective system of improving efficiency.

Gain by Use of Reheaters.

It is certain that where producing superheating, cylinder condensation in the cylinder receiving steam through them will be reduced. It is known that with large engines, such as are commonly fitted with these adjuncts, a superheat of 50° to 100° F. will reduce this waste to an insignificant quantity. Experiments with steam jackets indicate that where the latent heat of steam of boiler pressure is employed in the reduction of cylinder condensation, each pound of such steam so employed saves on an average considerably more than its own amount. General experience would seem to show that in the class of engines here studied the net result should be expected to be a net saving of from two to four or five pounds of steam worked in the engine for each pound thus expended, averaging in actual reported practice probably not far from three. The first datum would show that 10% added heat in the form of superheat of originally "dry and saturated" steam saves about 20% of the total expenditure in the engine. The latter datum indicates that 10% should in this manner save 30 or 33%, where cylinder condensation attains any greater magnitude than this proportion of total steam supplied.

Reheaters on a compound engine, however, can only affect the low-pressure cylinders, and alone should be expected to save perhaps half the cylinder-condensation loss, which is in such engines usually not far from 20% in compound and 15% in good triple-expansion engines. A net 10% in the one and 5% per reheater in triple and quadruple-expansion engines should not be too high a preliminary estimate.

Reheaters have usually been employed both as separators and drying apparatus, and as superheaters, being introduced into the steam pipe, or the steam connection between cylinders, and supplied with high-temperature steam, or with heat from the flues or smokestack in sufficient amount to give them the desired efficiency. If properly arranged, complete separation will be first effected, and the steam thus dried will be then raised to a temperature considerably in excess of that of the saturated steam coming into the reheater. Every good reheater is, in fact, a superheater for the next succeeding cylinder. The degree of superheat secured is usually, in the best cases, not less than 50° F.

The reheater in a current of wet steam, where unequal to the task of drying and markedly superheating that steam, cannot be expected to prove economically useful. The duty of the reheater may thus be reckoned as the sum of two distinct actions: the drying of wet steam and superheating of the steam thus dried.

Since the receiver cannot act as a reheater effectively, or produce any gain, apparently, unless by superheating, it is evident that all moisture should be taken out of the steam before it enters the reheater. A separator receiver, capable of perfect drainage, between the small cylinder and the reheater, is thus, in many cases, likely to prove an advantage.

*Condensed from a paper presented at the Cincinnati meeting of the American Society of Mechanical Engineers.

†Director of Sibley College, Cornell University, Ithaca, N. Y.

The purpose of the steam jacket, the superheater and the reheater is the same with all, and they all necessarily act in a similar manner—first drying the steam, if wet, then giving it so much of superheat as to sensibly reduce the amount of initial condensation during the first stages of the action of the fluid in the engine. Whichever is employed, or if all are used, the use of a system of separation as a preliminary to the superheating is economically desirable, as re-evaporation of the entrained moisture is best performed in the boiler, to which the separator should send it directly and without loss of heat en route.

THE PINEY BRANCH VIADUCT, WASHINGTON, D. C.

By Thos. C. J. Baily, Jr., C. E.*

The accompanying illustrations show the main structural features of the new viaduct which the District of Columbia has recently constructed to give access by roadway to Rock Creek Park, lying nearly north of the thickly-settled portion of the city of Washington. At present the only practicable approach to the park from the south is by the Linnean Hill Road, which, after reaching an elevation of 198 ft. at 18th St., crosses Piney Branch near its junction with Rock Creek, at an elevation of 69 ft., and then rises to 93 ft. above tide level, giving at one place a grade of over 10%. This road is largely used not only for pleasure driving and bicycling, but also by heavy teams. It was for the purpose of rendering easier this approach to the park that the Board of Control decided to construct a cut-off line to the east, throwing a high-level bridge over the Branch.

The Piney Branch valley at this point is between 300 and 400 ft. wide and 60 ft. deep, and is heavily wooded. The type of bridge decided upon consisted of a series of deck trusses resting upon steel trestle bents, the spans to be as shown by the elevation, Fig. 1, making a bridge 300 ft. long between centers. The distance apart of the trusses was to be 16 ft., with a 24-ft. roadway between railings and no footwalks. The height of the trusses was to be 10 ft. on centers, and all panel lengths 15 ft.

The floor system was to consist of 15-in., 42-lb. I-beams, 5 × 14-in. Georgia pine stringers, 16 ft. long, notched ½-in. over the floor beams and spaced 2 ft. on centers, with 3-in. Georgia pine planking. The truss was to be designed for a moving load of 100 lbs. per sq. ft., or twelve tons on two axles, 7½-ft. centers, and a wind pressure as designated in the 1896 edition of Cooper's "General Specifications for Steel Highway Bridges and Viaducts."

For the abutments bids were invited on two plans. The first (upon which the bridge was built) consisted in excavating and stepping to a solid foundation, filling to the natural surface with a dry rubble consisting of large stones placed by hand in level courses, the interstices being carefully filled with smaller stones. Upon this a rubble fill was to be formed in the same manner as the foundation, except that the stone was to be embedded in cement mortar consisting of one part Portland cement and four parts of sand. This fill on slopes of 4 ins. to 1 ft. was to be topped with 18 ins. of concrete composed by volume of one of Portland, two of sand, three of pebbles, four of stone.

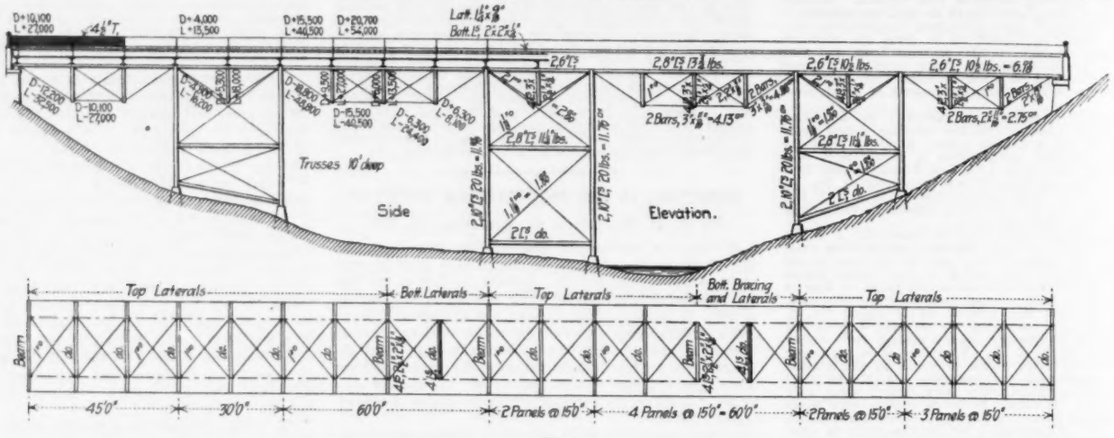
On this the masonry abutments, Fig. 2, were to be built in courses of not less than 12 ins. with one to two Portland cement mortar, and topped with a granite coping. The rubble fill was to project one foot all around beyond the base of the abutment and back wall. An 18-in. Maryland granite coping topped the back wall with a 15-in. coping on the abutment.

The second or alternative plan consisted in resting the trusses on two concrete pillars or piers 16 ft. apart on centers, with a back wall on the fill. These piers were to be 3 ft. 9 ins. square, with a granite coping, and to rest on a 4-ft. 9-in. footing course. The earth fill was to run between the piers.

The concrete piers for the trestle bents were carried down about 4 ft. A footing course, 4 ft. 3 ins. square × 1 ft., was topped by a course 3 ft. square × 1 ft., on which was placed a 2-ft. concrete shaft topped with a 15-in. granite coping, 2 ft. 3 ins. square. Built into the concrete on each pier were two 1⅛-in. anchor bars 3 ft. long. The proportions of the concrete were one, two, three and four. On account of its close proximity to the stream the concrete in the east pier of bent number 4 was enriched to the proportions of one, two, two and three. The south abutment and most of the trestle piers were founded on solid rock. The maximum pressure on the concrete when the bridge is fully loaded can never be over 9.7 tons to the square foot, and the pressure under the foundations can never be more than 2.5 tons to the square foot. There have been no evidences of any settlement.

The contract for this bridge was awarded to the Toledo Bridge Co., of Toledo, O., the Osborn Co., of Cleveland, O., inspecting the steel. The superstructure was carefully scraped and given two coats of Atlantic Alcatraz asphalt paint, the color being a dark olive green. The erection was very simple. A wooden trestle bent being raised by the traveler and guyed, the members were s[illegible] into place and supported by this bent. On a[illegible] difficulty in obtaining timber the bridge was not completed until Jan. 31, 1900.

The cost was as follows: Foundations, concrete, masonry, filling, etc., $2,111 [illegible] including which should be deducted 87 barrels of [illegible] from cement furnished the contractor by the [illegible] District at $2.50, or $217.50, leaving $1,894.40 received by contractor; trestle bents complete, $2,820; superstructure complete, $5,635; total, $10,349.40 received by contractor. The itemized prices were as follows: Excavation, 24 cts. per cu. yd.; earth filling, 26 cts. per cu. yd; stone masonry, $6 per cu. yd.; stone coping, $30 per cu. yd.; concrete, $3.25 per cu. yd.; a total of 43,500 lbs. of steel were used in the trestles, and of 77,700 lbs. in the trusses, making a grand total of 121,200 lbs. About 46,080 ft. B. M. of lumber were employed. The bridge, while having no pretense to architectural beauty, well suits the locality, especially on account of its airiness. It will be noticed how heavy the flooring is. This was made so on account of the comparatively heavy traffic and because road rollers were likely to use the bridge. The maximum grade on the new line is 4.4% against 10% on the old road. The floor is 58 ft. above Piney Branch at ordinary stages.



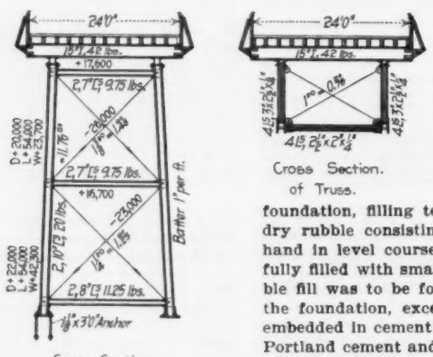


FIG. 1.—DIAGRAM PLAN AND ELEVATIONS OF PINEY BRANCH VIADUCT, WASHINGTON, D. C.

Capt. Lansing H. Beach, U. S. Engineers, Engineer Commissioner, District of Columbia.

Toledo Bridge Co., Toledo, O., Contractors.

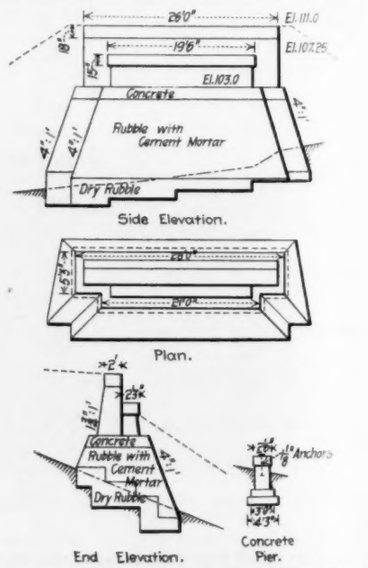


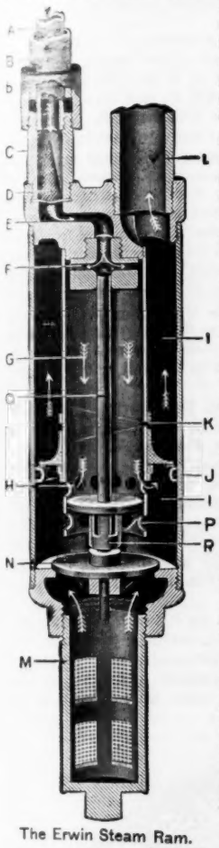
Fig. 2.—Abutments and Piers for Piney Branch Viaduct, Washington, D. C.

*1207 Lydecker Ave., Washington, D. C.

The bridge was built under the direction of Captain Dunsing H. Beach, Corps of Engineers, U. S. A., Engineer Commissioner, District of Columbia, Mr. Wm. P. Richards, in charge of the Improvements of Rock Creek Park, being in control and determining the location, type and general proportions of the structure. Mr. Thos. C. J. Baily, Jr., prepared the plans on which the bids were asked, and had charge of the erection. The Toledo Bridge Co., of Toledo, O., made all the details for the structural work and erected the bridge.

NEW STEAM PUMP FOR USE IN WELLS.

We show in the accompanying illustration a new type of steam pump which has recently been brought out by the Penberthy Injector Co., of Detroit, Mich. Like the pulsometer, it is very simple in operation, and is especially suited for use in places where little attention can be given to it.



The Erwin Steam Ram.

The Penberthy Injector Co., Detroit, Mich., Manufacturers.

It is made in two styles, one of which is intended to operate against a head of as much as 60 ft., and the other up to 40 ft. To operate the device at the maximum head a steam pressure of about 75 lbs. is necessary. Its manner of working is described as follows, referring to the letters in the cut:

The ram is placed beneath the surface of the water in the well or other source of supply, and, before starting, water flows into it by gravity. When steam is turned on it passes through the steam pipe A, nipple C, conical screen D, main steam port E, and radial steam ports F, into the cylinder G. The water is then forced downward through the openings H into the surrounding discharge chamber I, where it passes through the annular check valve J and out of the discharge pipe L.

When the steam driving out the water ahead of it reaches the lower end of the cylinder G, it is exhausted through the large openings H much faster than it is admitted through the small steam ports F, is condensed in the surrounding discharge chamber I, and a partial vacuum is formed within the cylinder G. The vacuum is made more complete by a spray of water which then rushes inward from the discharge chamber I through the small opening K.

The instant a vacuum is created and condensation occurs the pressure on the water outside of the ram forces water upward through the bottom strainer M. The main check valve N then rises and the valve rod O, which is rigidly attached to it, shuts off the steam at the upper end of the cylinder. The entering water passes through the openings P, forces up the float R, which moves freely on the valve rod O, and refills the cylinder.

The entering water having lost its momentum, the steam acting downward on the valve rod, closes the main check valve, and through pressure exerted on the float, again forces water out of the cylinder and through the discharge chamber and discharge pipe.

A covering pipe B, surrounds the steam pipe for the distance it is submerged beneath water, to prevent condensation and is received into the coupling b.

The following results were obtained in tests:

	Ram	
	Low-lift.	High-lift.
Diam. inner or steam cylinder, ins...	2½	1¾
Diam. outer or water cylinder, ins...	3½	3½
Steam used, lbs.	186.3	70.3
Water delivered, lbs. 17,152		6,675
Distance water was elevated, ft.....	42.8	61.6
Water raised 1 ft. per 1 lb. steam, lbs.	4,000.5	5,959.1

These figures correspond to duties of about 4,000,000 and 6,000,000 ft. lbs. per 100 lbs. of coal, respectively. The advantage claimed for the system arise from the almost total absence of moving parts, and the compactness and extreme simplicity of the device, making it available for small bored wells. As there are no rubbing parts, it can handle water carrying sand or acids to especial advantage, and while the ordinary deep well pump would doubtless surpass it in economy when in good order, it is well known that the difficulty of repairing and adjusting such pumps often causes them to be kept running with valves and pistons badly worn and leaking; and the advantage in economy of the direct-acting pump may thus disappear in actual use.

The ingenuity with which the apparatus has been designed, and especially the manner in which the steam valve is opened and shut by fluid pressure alone, are exceedingly interesting, and deserve much praise.

WATER-SOFTENING PLANT AT THE LORAIN STEEL COMPANY'S BLAST FURNACES.*

By N. O. Goldsmith.†

The water supply for the works of the Lorain Steel Co. is taken from the Black River. In most seasons of the year it contains considerable mud and silt in suspension, and at all times soluble impurities. Analysis of the water made in April, 1898, shows the soluble impurities as follows in grains per United States gallon:

Organic matter	1.830
Oxide of iron and aluminum	1.275
Carbonate of lime	3.244
Carbonate of magnesia	1.622
Sulphate of lime	7.455
Chloride of magnesia	1.124
Total	16.548

This water forms a scale in the boilers, which is quite hard and difficult to remove. At the steam plants of the shape mill and bessemer department mechanical purifiers were used, and also tube-cleaning machines. At the same time a number of different boiler compounds were tried, but the boilers still contained a heavy scale.

When the new blast furnace was erected it was decided to try a more scientific method of purifying the water, and one which would remove the incrustating solids before the water reached the heaters or the boilers. A chemical process involves an expense due to the reagents used; therefore in order to keep down the cost to a minimum only the cheapest and most efficient reagents can be employed.

Table of Cost of Precipitating 1,000 Grains of Different Impurities with Different Reagents.

Reagent.	Cost, reagent, pr lb., cts.	Carbonate—Lime, cts.	Carbonate—Magnesia, cts.	Sulphate of lime, cts.	Chloride of magnesia. cts.
Caustic lime	0.3	0.025	0.029	.....	.....
Soda ash, 58%	1.5	.....	.....	0.167	0.243
Caustic soda, 74%	3.0	.357	.407	.....	.....
Tri-sodium phosphate.	6.0	.942	1.113	.691	.997

The Clarke process of precipitating carbonates of lime and magnesia by means of caustic lime, is undoubtedly the cheapest chemical method; that combined with soda-ash treatment for the sulphates and chlorides, makes it possible to get a clear feed water low enough in scale-forming matter to fulfill all requirements.

True water softening is an exact process; by this is meant that the exact amount of caustic lime must be put in the water to remove all the carbonate of lime and magnesia present; and the exact amount of soda ash used to decompose all the sulphate of lime and chloride of magnesia. No more, no less.

The method of treating the water, and the apparatus used, must be so simple that a man can operate it who has no knowledge of chemistry, and of whom nothing but mechanical work is required, if it is desired to run at the lowest possible cost for operation.

If a continuous process plant is used, in which solutions of the caustic lime and of soda are made continuously, and added to a constantly moving supply of water, an exact and uniform treatment is more difficult to obtain. (1) Because the amount of caustic lime or of soda ash dissolved in a gallon of the solution may vary. (2) Because the change of pressure may vary the amount of raw water supply, changing the whole character of the effluent. (3) Because it is a difficult matter to keep uniform the amount of the chemical solutions flowing through the small orifices into the raw water. (4) Because the only means of determining when the water is treated with the correct amount of caustic lime is by the depth of color given by using a chemical indicator; and no acurate means is known to determine the correct amount of soda ash used, except chemical analysis, which could not be furnished soon enough to be of any benefit. An intermittent settling tank plant, therefore, permits more accurate and uniform treatment, and is much simpler to handle. The only question is the matter of mixing the chemicals thoroughly with the water; this is accomplished satisfactorily by stirring.

In the blast furnace water-softening plant, four open-top settling tanks are used, each 30 ft. in diameter, by 20 ft. high; they are built of steel, and each has a net capacity of 95,000 U. S. gallons. Each is provided with a mechanical stirring or mixing device; this consists of two armed paddles placed at the bottom of the tank, fastened to a vertical shaft which is operated by gearing driven by small steam engine; the paddles made about six revolutions per minute. This thoroughly mixes the chemicals with the water, and the stirring of the water always hastens the chemical reactions, as any chemist well knows.

The uniformity of treatment results from the fact that a constantly uniform quantity of water is treated in each tank, by weighing out the correct amount of the dry caustic lime and of soda ash required for each tank, and adding these to the water. To show the theoretical delicacy of this method, there is no trouble in weighing either of the dry chemicals, to ½ lb., equal to 3,500 grains. A treating tank holds 95,000 gallons, therefore the personal error per gallon is .034 grains for each reagent used. In practice this is effected to a slight degree by the variation in the quality of the caustic lime; in the case of the soda ash, however, there is no loss. The amount of each reagent was determined when the plant was started, by chemical analysis, checked up by many analyses of the treated water. All that is necessary then is for the operator to add the same quantity of caustic lime and soda ash to each tank treated, until a change in the raw water requires a change in the amounts of the reagents used.

These variations in the amounts of soluble impurities are more frequent in surface waters than in waters from deep wells, but in any case, it is not a daily, but rather, a weekly or monthly one. Samples of the treated water are sent to the laboratory about once or twice a week and the water tested; any change is made only on instruction from the chemist.

To show the uniformity of the character of the treated water, the following table is given. The analyses were made in the laboratory of the Lorain Steel Company.

Date, 1899.	Grains per U. S. gallon.—Raw water.—Lime (CaO).	Raw water.—Magnesia (MgO).	Softened water—Lime (CaO).	Softened water—Magnesia (MgO).
July 24	4.0	1.3	0.4	0.7
July 25	4.0	1.4	.5	.9
Aug. 10	3.6	1.4	.4	.7
" 17	4.1	1.6	.5	1.0
" 26	4.0	1.5	.4	1.0
Sept. 4	4.0	1.5	.4	.7
" 8	3.9	1.4	.4	.7
" 9	3.9	1.5	.6	1.3
" 11	...	...	.6	1.2
" 12	...	...	.5	1.3
" 14	...	...	.4	.6
" 21	4.0	1.4	.6	.8
" 22	...	...	.4	.5
" 25	...	...	.5	.8
" 29	4.0	1.5	.6	.9
Oct. 9	...	...	.7	.8
" 20	...	...	.5	.7
" 27	...	...	.5	.8
Averages	3.95	1.45	0.5	0.85

Another very important advantage of the use of treating tanks is the fact that, when properly proportioned, they allow the water to stand in them long enough to complete the chemical reactions; inasmuch as no chemical action is instantaneous, therefore time is necessary in order to get a complete precipitation and a corresponding purification of the water which is being treated. By using hot water this time is shortened. The water from the hot well of the blowing-engine condensing plant is pumped into the settling tanks; this water is from 90° to 96° F. To further raise the temperature of the water a system of heating coils is put in each treating tank; the exhaust steam from the pumps passes into these coils, raising the temperature of the water 114° F.; the condensed steam passes into the clear-water well. When the plant was put up, iron pipe was used in these heating coils, but experience proves that nothing but brass or copper pipe should be used for this purpose.

Having considered all the conditions necessary for accurate and uniform treatment, and for complete chemical reaction, the next problem is the mechanical one of separating the lime sludge precipitated from the water. The amount of sludge in water-softening plants is much larger than in ordinary filtration plants, because the soluble impurities as well as the suspended matter are removed, and, furthermore, the caustic lime used is also precipitated, therefore subsidence is necessary before the water can be passed to the filters. The settling tanks act as subsiding basins as soon as the stirring device is stopped and the circulation of the water ceases. It is found to be more economical in ground space and first cost, to use filters for the final clarification, than to use settling tanks of such size that the water will stand in them long enough to clarify perfectly by sedimentation. Furthermore, in this plant the sludge of previous precipitations is left in the tanks; this is mixed with the water of the next treatment and gathers up the new

*Condensed from a paper presented at the Cincinnati meeting of the American Society of Mechanical Engineers.

†Vice-President, We-Fu-Go Co., Smith and Augusta Sts., Cincinnati, Ohio.

finely divided precipitate into larger flakes, which settle more rapidly, and materially hastens the clarification of the water.

To cut down the amount of sludge thrown upon the filter beds to a minimum, hinged floating outlet pipes are used, the inlet to which is held about 18 ins. from the top of the water; these pipes rise and fall with the water levels; they are limited in their lowest horizontal positions by means of a chain and counterweight at the top of the tanks. In their lowest position they clear the paddles of the stirring device, leaving about 24 ins. of water always in the tank; in this water is collected the precipitated sludge. When this sludge becomes deep enough to prevent the easy rotation of the paddles, it is washed out by starting the paddles, mixing up the sludge with the water left in the tanks; in this condition it flows freely out of wash pipe to the sewer. The washing of each tank of this plant is done once a week, and it takes about 20 minutes to do this. The total waste or wash water used for this purpose is about 1.3% of the total amount purified.

From the treating tanks the water passes by gravity down the floating outlet pipe into the filters. There are two filters, each 16 ft. in diameter by 7½ ft. deep, having a total area of 400 sq. ft. of filtering surface. The filter tanks are made of steel with double bottoms; in the upper bottom are placed the sand strainers, made of brass, having aluminum bronze screens and riveted with copper rivets. The upper and lower bottoms form a clear water compartment, to which the outlet pipe is connected. The advantage of the upper bottom as a strainger diaphragm is that a uniform pressure is gotten upon all strainers when the bed is washed, and a more uniform distribution of work over the whole filter-bed is maintained while filtering; this is most difficult to get in a nest of strainer piping, due to frictional resistance of the pipe. The water flows on to the filter-bed through a central pipe, the level being kept uniform by a float controlling the regulating valve in the supply pipe. The filtering medium is crushed and graded quartz of uniform size and about 3 ft. thick over the strainers.

The filters are provided with mechanical stirring devices, having the usual revolving rakes driven by a train of reduction gears and operated by a belt. These stirring devices are turned only when the filters are washing, by the upward current of water taken from the settling tank. It is found necessary to wash a filter once every week, and it takes about twenty minutes to wash one. It requires 20,000 gallons to wash one filter, equivalent to 1.2% of the total amount of the water purified, to wash the two filter tanks. The total wash water required for the plant is about 2.5% of amount purified.

From the filters the water flows by gravity to the clear-water well, from which it is pumped by a low-lift duplex pump into the open heaters.

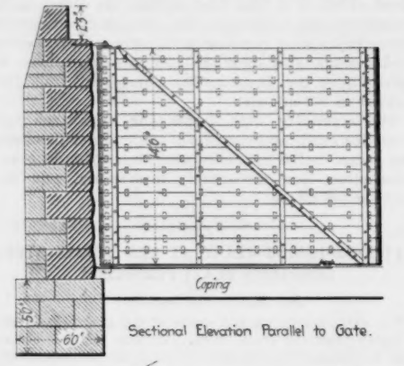
All piping between the settling tanks, filters, and clear-water well is set in a brick-lined pit, with a concrete floor. Only cast-iron flanged pipe and fittings are used, and flanged gate valves with outside screw-valve stems, fitted with valve-rod extensions, having cast-iron floor stands and indicators. These floor stands are placed upon floor over valve pit.

The pumps, filters and operating floor are in a cross-shaped building, constructed with a steel frame, covered with corrugated iron. The top of each settling tank is reached from the main floor by means of a stairway and bridge between the tanks. From the platforms connected by the bridge, the chemical tanks are charged by the operator, and the water is treated and tested. The plant is operated by one man for each 12-hour shift.

In addition to the purification of the feed water before it reaches the boilers, another matter must be considered, if it is expected to keep the boilers in the best possible condition; this is the concentration of the impurities of the water, due to the evaporation and passing off of practically pure water, thereby increasing the percentage of the impurities left in the softened water. The concentration of the soluble salts as well as those of lime and magnesia, is also important, for, although the former do not cause hard scale, because of their great solubility, they do cause foaming and even corrosion when present in the water in larger amounts.

The formation of scale must be due to heat, pressure and concentration to a degree where even the more soluble salts of lime and magnesia are finally precipitated; this condition takes place only in the boilers. By using a feed water very low in lime and magnesia salts, the length of time the boilers can be run before saturation is finally reached, becomes greater; therefore boilers can be run longer without washing out, and the expense of operation is decreased.

To lengthen the intervals between washing out, made necessary by concentration to a dangerous degree, it is found that regular blowing down of water from one to two gages, depending upon the type of boiler, and pumping up fresh water, is decidedly beneficial. There are twenty-two Cahall vertical boilers, 250 HP. each, at the blast furnace plant; in normal working condition each of these holds 292 cu. ft., equal to 2,200 U. S. gallons. When six inches are blown down, about 100 gallons of water are discharged; if this is done every 12 hours in 11 days, an amount equal to the entire capacity of the boiler is blown away. The objection to blowing out hot water and pumping in cooler water is recognized as not being an economical practice, but it is one of the penalties steam users must pay when they are compelled to use water containing comparatively small amount of soluble impurities, and want to keep their boilers free from scale. Therefore, in order to get the best condition, it is necessary to make chemical analyses, not only of the raw water and the treated water, but also of the concentrated water from the blow-off cock. This should be started when



Plan and Elevation of Flood-Gate at the River End of the Brock St. Tunnel, Montreal, Canada.

clean boilers are put in service, and samples should be taken at regular intervals, and the concentration watched; by this means it can be determined how long it is safe to run without washing; this interval will vary with the condition of the raw water at different locations, as upon the raw water depends the character of the softened water.

If the length of time between boiler washings can be increased three or four times over what was necessary before softened water was used and regular blowing-down put in practice, and if it is found unnecessary to use scrapers or tube-cleaning machines at all, because no scale accumulates or builds up; if open-exhaust steam heaters can be run from six months to one year without cleaning; if no live steam purifiers are required, and no boiler compound used, then by the use of softened water the percentage of idle capital is decreased, the labor of cleaning boilers, heaters, purifiers is decreased. And the fuel economy is increased, first, because a clean heater gives hotter feed water; second, the fuel used to heat up a cold boiler is more than that used to keep steam in a hot one.

A STREET TUNNEL WITH A FLOOD-GATE, MONTREAL, CANADA.

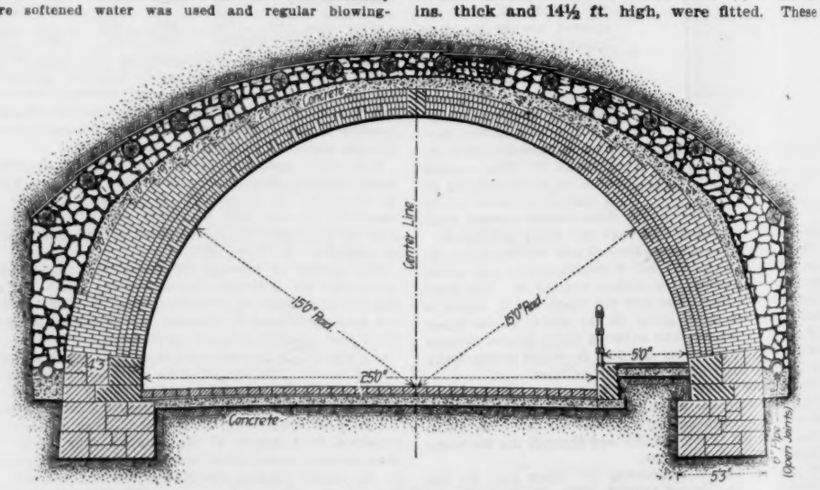
In a recent paper read before the Canadian Society of Civil Engineers, Mr. Stuart Howard described the construction of the Ontario and Berri Street subways, Brock Street Tunnel and Notre Dame Street Viaduct, in the city of Montreal.

The Brock Street Tunnel is especially interesting in possessing the novel feature of a flood-gate, at the river end, intended to keep out the water and ice during freshets in the St. Lawrence River. This tunnel approach to the wharf level was built to overcome very steep gradients in the natural surface approach, which seriously interfered with heavy hauling. It commences at Craig St. and with its approaches it has a total length of 995 ft., or 666½ ft. from portal to portal of tunnel proper.

The tunnel-arch is a semicircle of 15 ft. radius, springing from the floor of the tunnel, and thus gives a center headway of 15 ft. The portals are masonry, extending back 8 ft., and the arch stones are toothed so that the brick courses are tied to them. The intrados of the arch is fire-brick, 9 ins. thick, and the backing is hard red-brick laid in cement mortar, 1 cement to 2 sand. On top of this brickwork is a 9-in. course of concrete, made of 1 cement, 2 sand and 4 stone; and over this concrete is placed No. 20 galvanized iron corrugated. The space between the tunnel and the tunnel-roof planking was carefully filled with stone laid by hand; this stone acts as a drain and any water leaking in from above is carried through this stone to a 6-in. open-jointed pipe, laid on a bed of concrete on the same grade as the tunnel. This grade is 1 in 43 from portal to portal of tunnel.

The difference of level between the wharf and the Craig St. portal is 21 ft.; while the highest freshet recorded in the river would rise 13½ ft. above the wharf. It was proposed to keep this water out of the tunnel by placing a flood-gate at the wharf portal. Although this gate was constructed, and put in place, as a matter of fact the water finds its way into the tunnel behind the abutments, and the only advantage of the gate is that it prevents ice from entering and injuring the walls.

The gate was applied as follows: On the outside of the wharf portal, hollow quoins were left in the recesses of the abutments, into which solid wooden gates, of the ordinary lock type, and 12 ins. thick and 14½ ft. high, were fitted. These



CROSS-SECTION OF BROCK ST. TUNNEL, MONTREAL, CANADA.

double gates closed against a 12-in. timber let into the miter-wall and well bolted; and this timber was put into place at the close of navigation, a 6-in. plank taking its place in the summer season. As the gate was one foot higher than the maximum rise in the river, it did not close upon the masonry at the top, leaving the portal face flat. The cost of this tunnel was $131,696.

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